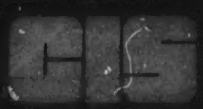
NOTE

This Microfiche meets the quality requirements of the American National Standard for Microfiche of Documents (ANSI PH5.9-1975). However, because of imperfections in the document from which it was made, it contains images that are illegible or difficult to read. The source document for this microfiche is the best copy that could be obtained prior to filming.



NASA'S FIVE-YEAR PLAN

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

JULY 26, 28, 1983

[No. 38]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
27-459 O WASHINGTON : 1983

H701-10

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
GEORGE E. BROWN, JR., California
JAMES H. SCHEUER, New York
RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
MARILYN LLOYD, Tennessee
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ALBERT GORE, JR., Tennessee
ROBERT A. YOUNG, Missouri
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
MERVYN M. DYMALLY, California
PAUL SIMON, Illinois
NORMAN Y. MINETA, California
RICHARD J. DURBIN, Illinois
MICHAEL A. ANDREWS, Texas
BUDDY MacKAY, Florida
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G. TORRICELLI, New Jersey
FREDERICK C. BOUCHER, Virginia
LARRY WINN, JR., Kansas
MANUEL LUJAN, JR., New Mexico
ROBERT S. WALKER, Pennsylvania
WILLIAM CARNEY, New York
F. JAMES SENSENBRENNER, JR., Wisconsin
JUDD GREGG, New Hampshire
RAYMOND J. McGRATH, New York
JOE SKEEN, New Mexico
CLAUDINE SCHNEIDER, Rhode Island
BILL LOWERY, California
ROD CHANDLER, Washington
HERBERT H. BATEMAN, Virginia
SHERWOOD L. BOEHLERT, New York
ALFRED A. McCANDLESS, California
TOM LEWIS, Florida

J. H. POORE, *Executive Director*
ROBERT C. KETCHAM, *General Counsel*
REGINA A. DAVIS, *Administrator*
DAVID S. JEFFERY, *Minority Staff Director*

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

HAROLD L. VOLKMER, Missouri, *Chairman*

BILL NELSON, Florida
MICHAEL A. ANDREWS, Texas
GEORGE E. BROWN, JR., California
RALPH M. HALL, Texas
MERVYN M. DYMALLY, California
NORMAN Y. MINETA, California
BUDDY MacKAY, Florida
ROBERT G. TORRICELLI, New Jersey
MANUEL LUJAN, JR., New Mexico
BILL LOWERY, California
ROD CHANDLER, Washington
HERBERT H. BATEMAN, Virginia
ROBERT S. WALKER, Pennsylvania

CONTENTS

WITNESSES

July 26, 1983:

	Page
Hon. James Beggs, Administrator, National Aeronautics and Space Administration	1
Lt. Gen. James A. Abrahamson, Associate Administrator, Office of Space Flight	23
July 28, 1983:	
Dr. Burton I. Edelson, Associate Administrator, Office of Space Science and Applications	60
Robert E. Smylie, Associate Administrator of the Office of Space Tracking and Data Systems	111
Dr. Raymond S. Colladay, Associate Administrator Office of Aeronautics and Space Technology	143

NASA'S FIVE-YEAR PLAN

TUESDAY, JULY 26, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9 a.m., in room 2325, Rayburn House Office Building, Hon. Harold Volkmer (chairman of the subcommittee) presiding.

Mr. VOLKMER. The meeting is called to order.

Today, the Subcommittee on Space Science and Applications begins 2 days of hearings to review the NASA 5-year plan.

The purpose of these hearings is to review NASA's long-range goals and how they fulfill the national policy as established in the National Aeronautics and Space Act of 1958. From this review the subcommittee hopes to gain a longer range perspective than is possible during our annual authorization hearings.

Our witnesses today will be:

The Honorable James M. Beggs, NASA Administrator, and Gen. James Abrahamson, Associate Administrator, Office of Space Flight.

I would add that there is a full committee meeting at 10:30 this morning and approximately at that time, the subcommittee will adjourn until Thursday afternoon, at 1 p.m. to continue the hearings.

Now, we will proceed with Mr. Beggs. You have submitted a statement and that statement will be made a part of the record in full. You may either review the statement in total or summarize, however you see fit.

It is good to have you here this morning.

Mr. Beggs.

STATEMENT OF HON. JAMES BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BEGGS. Thank you, Mr. Chairman. I am delighted to be here. I do appreciate the opportunity to discuss with you NASA's planning for the next 5 years and with your permission, I will summarize this statement; it is quite long.

The briefings today and tomorrow, I guess, will cover the planning for space flight, space technology, space science and applications, and space tracking and data systems programs. The planning

we have been doing on the space station, which as you know has been ongoing for about 1 year now, is not included, as we will be testifying before you on that subject at considerably greater length at hearings next month.

The planning for the NASA's program as far as looking ahead at least 10 to 20 years, and sometimes even further, because the programs that we conduct in pioneering and exploring new frontiers and applying our knowledge to more utilitarian purposes, generally are long cycle programs and generally range anywhere from 7 years to 10 to 15 years to complete. Each of the program areas on which we will be briefing will include our long-range planning, and will also, of course, discuss projects to be undertaken in the nearer term. Experience has convinced us that our detailed program planning should concentrate, however, on programs to be initiated in the next 5 years. Thus, we are in the habit of referring to our long-range planning as "5-year planning."

In 1976, NASA began its present formal process of developing 5-year plans. The first result of this comprehensive effort was the plan for the fiscal 1978 through 1982, and 5-year planning has been conducted each year since then. The annual process begins each spring with review by the senior headquarters and field installation managers of proposals from NASA's program offices describing their plans for the budget year to be presented to the Congress the following January. Then, of course, it goes on to include the budgets for the ongoing years. It is made then, once we have come to an agreement with the OMB, a part of the President's annual budget submitted in January. The annual planning process, I have found, is of great value not only for setting forth policies and goals on a continual basis, but also for providing a measure of present achievement. It does provide a framework in which program budgets can be constructed and objectives can be set and these provide a basis for selection of a total program for submission to OMB and the President, and eventually the Congress.

At this time, I believe it is worth noting that NASA's 5-year plan reflects consultation with the Space Science, Space Applications, and Aeronautics and Space Engineering Boards of the National Academy of Science and the National Academy of Engineering; the NASA Advisory Council and its committees; and other leaders in industry, universities, and non-governmental research associations. And just as an aside to that, Mr. Chairman, as you know, this kind of advisory counsel system has been in being for 68 years since the NACA came into being and, it has served this Agency and the country very, very well. We continue it, we value it.

It is of course, the major objective of this Agency to give high priority, and indeed the highest priority, to making the Space Transportation System fully operational and cost effective in providing routine access to space. For the civil space program, the program that we have outlined covers research, development, operations, and exploration for science, applications, and technology. It also calls for providing a climate conducive to expanding private sector involvement; continued international cooperation where benefits accrue to the United States and to the foreign governments; and management of Federal civil operational remote sensing systems by the Department of Commerce.

As you know from our testimony in hearings on the subject in May, we have the issues of commercialization under serious study. We have published and we have had extensive discussions with the industry on the commercialization opportunities, particularly in the expendable launch vehicle area.

The administration's aeronautical research and technology policy, released in November 1982, reaffirms the Government's role in supporting aeronautical research and technology both civil and military. The policy also recommends maintenance of the present institutional framework, in which NASA's role is to fund, direct, and conduct aeronautical R&T development programs; to support military aeronautical technology demonstrations, and with the Department of Defense, to manage, maintain, and operate aeronautical research, development, test and evaluation facilities. This is consistent with our role as a civilian research and development agency.

Finally, last year to assist us in focusing our plans for the future, we drafted a list of major goals which provide a common base for the full range of NASA's effort. They have been discussed with senior members, both, managers both at headquarters and at the NASA's field installations and have been modified to reflect the valid comments received. The goals are responsive to the National Aeronautics and Space Act of 1958 and consistent with the national policy. And, they will continue to evolve but they are currently expressed as follows:

First, provide for our people a creative environment, the best of facilities, support services, and management support so they can perform with excellence NASA's research, development, mission, and operational responsibilities.

Second, make the space transportation system fully operational and cost effective in providing routine access to space.

Third, continue to explore the requirements, operational concepts and technology associated with permanent space facilities.

Fourth, conduct an effective and productive aeronautics research and technology program which contributes materially to the enduring preeminence of U.S. civil and military aviation.

Fifth, conduct an effective and productive space and earth sciences program which expands human knowledge of the earth, its environment, the solar system, and the universe.

Sixth, conduct effective and productive space applications and technology programs which contribute materially toward U.S. leadership and security.

Seventh, expand opportunities for U.S. private sector investment and involvement in civil space and space related activities.

And finally, establish NASA as a leader in the development and application of advanced technology and management practices which contribute to significant increases in both agency and national productivity.

Mr. Chairman, each of the programs, you will hear described in these hearings is linked closely to one or more of these goals.

We believe our current plans and the more specific programs, to be presented to the Congress in January, will contribute materially to the national goals and objectives espoused in the national space

and aeronautics policy and to the Nation's strength, security and vitality.

Thank you very much, Mr. Chairman.

[The prepared statement of Hon. James Beggs follows:]

Statement of

James M. Beggs
Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to discuss with you NASA's planning for the next five years and to provide the background for the briefings this afternoon and tomorrow by each of NASA's program Associate Administrators. The briefings will cover NASA's planning for Space Flight, Space Technology, Space Science and Applications, and Space Tracking and Data Systems programs. Space Station planning is not included because we will be testifying before you on that subject in considerably greater detail in Hearings early next month.

Planning for NASA's programs requires looking ahead 10 to 20 years, and sometimes even further, because the programs consist of pioneering work to explore new frontiers in space science, to apply the space environment for utilitarian purposes, and to develop the new technologies required for conducting those science and applications activities. Each of the program areas on which you will be briefed includes such long-range planning, and it is essential as a basis for establishing the optimum characteristics for projects to be undertaken in the nearer term. However, experience has convinced us that our detailed program planning should concentrate on programs to be initiated chiefly in the next five years. Thus, we are in the habit of referring to our long-range planning as "five-year planning."

In 1976, NASA began its present formal process of developing five-year plans. The first result of this comprehensive effort was the plan for FY 1978 through 1982, and the five-year planning has been conducted each year since then. The annual process begins each spring with the review by senior Headquarters and field installation managers of proposals from NASA's program offices describing their plans for the budget year to be presented to the Congress the following January, and for the next four years. On the basis of that preliminary planning, budget proposals are developed during the summer and submitted to the OMB in September. As modified by further negotiation, this becomes part of the President's budget submitted to the Congress in January. The plan then is completed and documented; and, at the same time, the planning process for the next year begins.

For example, while the report for FY 1984 through 1988 has just been released, we are well into planning for FY 1985 through FY 1989.

This annual planning process is of great value not only for setting forth policy and goals on a continuing basis, but also for providing a measure of present achievement. It also is essential to establish the framework on which program budgets are constructed. The briefings that follow today and tomorrow underscore the current concepts of our program offices for the five-year planning period starting with FY 1985. These will provide the basis for the selection of a program for submission to OMB and the President in September.

At this time, I believe it is worth noting that NASA's five-year plan reflects consultation with the Space Science, Space Applications, and Aeronautics and Space Engineering Boards of the National Academy of Science and the National Academy of Engineering; the NASA Advisory Council and its committees; and other leaders in industry, universities, and non-governmental research associations.

The programs under consideration follow logically those underway or initiated in the budget for FY 1984 approved recently by the Congress and are consistent with the policies stated last year by the Administration on space and on aeronautical research and technology. The Administration's space policy, announced on July 4, 1982, gives high priority to making the Space Transportation System fully operational and cost-effective in providing routine access to space. For the civil space program, it outlines a balanced strategy of research, development, operations, and exploration for science, applications, and technology. It also calls for providing a climate conducive to expanded private sector involvement, continued international cooperative activities where sufficient benefits accrue to the United States, and management of federal civil operational remote sensing systems by the Department of Commerce.

As you know from our testimony in Hearings on the subject in May, we have the issues of commercialization under serious study. Shortly after we began that study, the Administration (on May 16, 1983) established the specific policy to commercialize expendable launch vehicle operations. This is being taken into account in our planning.

The Administration's aeronautical research and technology policy, released in November 1982, reaffirms the Government's role in supporting aeronautical research and technology (R&T) development (both civil and military). The policy also recommends maintenance of the present institutional framework, in which NASA's role is to fund, direct, and conduct aeronautical R&T development programs; to support military aeronautical technology demonstration programs; and, with the Department of Defense, to manage, maintain, and operate aeronautical research,

development, test, and evaluation facilities. This is consistent with NASA's character as a civilian research and development agency.

Last year, to assist us in focusing our plans for the future, we drafted a list of major goals that would provide a common base for the full range of NASA's efforts. They have been discussed with senior managers both at Headquarters and at the NASA field installations and have been modified to reflect the valid comments received. The goals are responsive to the National Aeronautics and Space Act of 1958 and consistent with national policy. They will continue to evolve but currently are expressed as follows:

- Provide for our people a creative environment and the best of facilities, support services, and management support so they can perform with excellence NASA's research, development, mission, and operational responsibilities

- Make the Space Transportation System fully operational and cost effective in providing routine access to space.

- Continue to explore the requirements, operational concepts and technology associated with permanent space facilities.

- Conduct an effective and productive aeronautics research and technology program which contributes materially to the enduring preeminence of U.S. civil and military aviation

- Conduct an effective and productive space and Earth sciences program which expands human knowledge of the Earth, its environment, the solar system, and the universe

- Conduct effective and productive space applications and technology programs which contribute materially toward U.S. leadership and security

- Expand opportunities for U.S. private sector investment and involvement in civil space and space-related activities

- Establish NASA as a leader in the development and application of advanced technology and management practices which contribute to significant increases in both Agency and national productivity.

Mr. Chairman, each of the programs you will hear described in these Hearings is linked closely to one or more of these goals.

We believe our current plans and the more specific programs to be presented to the Congress in January will contribute materially to the national goals and objectives espoused in national space and aeronautics policy and to the Nation's strength, security, and vitality.

Thank you.

Mr. VOLKMER. Thank you very much, Mr. Beggs.

How do you view NASA's role in the, you gave those goals, in expanding opportunities for U.S. private sector investment and involvement? How do we go about doing that?

Mr. Beggs?

Mr. BEGGS. Well, I think we have got to do several things. The most important of which actually is to change our minds a little bit as to the way we deal with the outside world. The commercialization, as it has been discussed and written, of space will result from entrepreneurial activity where venture, capital, and creative minds are put to work to explore the various things that we discover or vistas that we open in our program and take advantage of them on their own.

I don't think the Federal Government, not even NASA which I consider to be a very innovative and creative organization, is of a character to decide ourselves what areas that are likely to be most conducive to commercialization or commercial development. That will come from the private sector. But, I do think it is incumbent on us to create a climate and to make it as easy as we can so that if someone comes to us with a proposal that we receive it with an open mind and that we try to facilitize that private sector involvement with all of the resources that we command.

Now, we do have in place a number of policies and procedures which are very conducive to that. The most important of which I consider to be the joint endeavor agreement whereby if someone wants to fly with us in any respect, we will sit down and write an agreement with him where, during the experimental phase or the test phase of his idea, we will fly them for free, in essence, providing they put up money of their own and pursue the idea with diligence and vigor. And that is very important. But, we also need to work very hard and General Abrahamson, I am sure will tell you, that we have been trying to put the burden on our centers to make it as easy as we can to simplify our procedures to enable them to fly as easily as they can on shuttle and get into the program without a great deal of red tape. And we have a way to go there.

Beyond that, I think that we need to work hard at transferring to the private sector the results of our research and technology. We have initiated over the past several years programs with the AIAA, American Institute of Aeronautics and Astronautics, a program of inviting a cross-section of American industry to each of our centers where we expose them to what we are doing and give them some idea of where our research and technology is leading us. But probably more important than that, letting them see the center and get acquainted with our people so that if they have an idea which is related, they know who to call and who to talk to in order to get into the NASA system.

And I should add, although I think it is listed in my statement, that that broad segment includes a lot of nonaerospace types. The aerospace industry knows how to work with us. They have been working with us for a long, long time and they are familiar with the Agency. But the nonaerospace types are not. It is my view that many, if not most, of the innovative commercial ideas will come from the nonaerospace sector. So we have got to get them better acquainted with what we are up to; with the research we are doing

and to make them acquainted with the people in NASA and its facilities so that they can be better able to bring a new idea to us and to get it into the system and fly.

Mr. VOLKMER. Where are we in relation to giving a kind of status report on the expendable launch vehicles, spinning those off?

Mr. BEGGS. I am a going to let General Abrahamson comment on this in a minute.

We have had, I guess, three or four proposals. We did go out with an announcement about a month or so ago. And, we are receiving expressions of interest as a consequence of that announcement. The announcement, in essence, said that we would make available the various assets of the Federal Government on our standard policy of payment for those and to see what kind of return we could get from the industry in taking over one or the other of those expendable launch vehicles. We have had some response to that and I will let General Abrahamson comment.

General ABRAHAMSON. Sir, the request for information we formulated was put forth in the Commerce Business Daily. The intent of doing that, of course, is to insure that all of the potential commercial people, including the ones that we had not talked to, would really formally be put on notice that we were interested and we are anxious to have them bring forward their proposals.

Of course, there have been a series of discussions with many of, or several of these organizations now for sometime. And, we have provided them guidance in terms of the preparation of their proposals. Formally, NASA put forward the information in the context of the NASA boosters which are the Atlas Centaur and the Delta and those are the ones that people are most interested in.

The request for expressions of interest in the commercialization of Centaur was answered by four companies: General Dynamics, FEDEX Space Transportation Co., CSC, AND UTC's Chemical Systems Division. The Delta request was answered by five companies: Space Services Inc., Transpace Carriers, FEDEX Space Transportation Co., CSC and UTC's Chemical Systems Division. RCA Service Co. expressed interest as a potential subcontractor only.

We are now in the process of preparing a more definite request on NASA's part for that proposal, but we are, we have encouraged them, and we have outlined for them the key elements of that so that they can be working on that ahead of time.

We expect to have this formal request for proposal ready early in August. The essence of it is so that everybody does have an equal opportunity that they will be asked to take over in a phased way so that they take over at the end of the presently, programed Government launches, but we also have provided them and encouraged them to offer an optional proposal which says come ahead and if you see a way that you can effectively move forward in time and propose taking over earlier then that, we would encourage you to do that.

So that really is the essence of the request for the proposal. We would expect that they will have on the order of 60 days to prepare a response and then early in the November timeframe, we will examine them for the keys, which really propose the best and most responsive system for the customers and also meet some of the

Government needs; and, there are Government needs which are legitimate and ongoing.

Mr. VOLKMER. Are all of these in a sufficient timeframe that they could take over the manufacturing facilities before they are shut down?

General ABRAHAMSON. In the case of Atlas Centaur and Delta, yes, sir. And in my briefing, I will show you that those can go on for some period of time.

Mr. VOLKMER. All right.

Mr. Beggs, I have one additional question.

In reviewing, and I haven't got through all of it yet, the 5-year program, but in seeing the number of possible starts, et cetera, and what we may be getting into as far, I don't want to get into specific details on space stations, but that and the possibility of fifth orbiter et cetera, where do you see the funding levels within the next 5 years necessary to fund those?

Mr. BEGGS. If we were to do everything in relation to where we are today; if we were to do everything that is in that 5-year plan, we would be talking about funding levels which would be on the order of a third to 40 percent higher than current levels. Obviously, we will have to tailor that program to the funding levels available.

I would make this one point though, Mr. Chairman, if I may which is that the real importance on budget in this Agency is in a continuing level of funding of real dollars over a significant period of time. The problem this Agency ran into in the seventies was that we were losing buying power at the time we were trying to do more things. If you look back to 1972, the Agency was receiving in budget authority about, I believe, $3.3 to $3.4 billion. In real dollars, that would equate to something in the order of $8 to $8.5 billion in 1984.

So, in essence, over the decade through the seventies and into 1980, or to put it more properly in 1982, we lost 15 to 20 percent of our buying power at the time we were trying to bring shuttle on line and trying to initiate and finish up programs like Galileo and all of the other things that we wanted to do.

And, you can't do that in this kind of a program. The programs are long cycled. Once you have committed to them, they require a steady level of funding and you do run into problems. We ran into problems on a thing like space telescope which you all are very familiar with and other budgetary problems in some of the smaller scientific programs. We had no reserves, at least reserves not sufficient to take care of those kind of problems. So, I would emphasize that in the future, what we would like is a higher level of funding. I have spoken a number of times that I would like to get the NASA budget back to where it was in the early seventies where it was 1 percent or so of the Federal budget. At that level, if we had it for 10 years or so, we would be able to do most of the program that we have outlined in the 5-year plan.

Mr. VOLKMER. Thank you very much.

The gentleman from Virginia, Mr. Bateman, would like to make a statement.

Mr. BATEMAN. Thank you, Mr. Chairman.

Mr. Beggs, you began this formalized 5-year planning process starting in 1976 and the first cycle, I guess, was through 1982. For

your next 5-year plan, how much of the agenda is carried over from the original 5-year plan or were you able to satisfy or complete all that was contemplated in that first 5-year plan?

Mr. BEGGS. Well, we are a long way along in the number of programs that were outlined in that first 5-year plan. We still haven't completed the major programs. Obviously, the shuttle is still ongoing, which is the major program, but it is, I am very pleased to be able to report that the shuttle is on very, very sound ground right now. And——

Mr. BATEMAN. That was always contemplated to go beyond that period.

Mr. BEGGS. Yes, sir.

Programs like space telescope and Galileo which were also in that time period, are continuing programs and we are aiming toward 1986 which emphasizes the point that I made earlier that most of what we do runs for 10 years or so to completion or to a point where you have a transition to a different phase or a new program.

We will initiate, however, in the 1984 time period, a couple of new programs: The Gamma Ray Observatory which was just in the early idea stage back there, and the Venus Mapper which comes into being in 1984. And, if we go ahead with space station at some time in the next few years, we will have another ongoing 8- or 10-year program which will start to appear in the planning.

Mr. BATEMAN. When do you anticipate having reached any decisions, at least, satisfactory to any essay with regard to the space station and the fifth orbiter?

Mr. BEGGS. Well, we have been conducting an extensive study for the last 12 months on the space station and we will submit those studies to the senior interagency group at the middle or third week in August. It will proceed from there to a paper which will be presented to the President with a number of options. Obviously, there will be a number of different choices as to ways we can proceed. That paper will also contain an additional discussion to fall within the lines of the discussion we had last fall on the fifth orbiter issue.

We have relatively little new information on the market. Now the market continues to develop in that we are now booking flights as far as 1988; and we are continuing to watch it very closely, but we have really no information that changes the market information that we had last fall. So, I doubt that there is anything new that we can add to that discussion. The only thing that might change in the consideration of that would be any requirements which DOD or others might have for extended flights and I have iittle information on that.

Mr. VOLKMER. Before we proceed, will the gentleman from Virginia yield just a minute.

I just want to point out that before we go into any details on this hearing on the space station, we have a hearing scheduled for next Tuesday.

Mr. Hodge will be here. He is chairman of that task force. At that time we can go specifically on the space station.

Mr. BATEMAN. That's all the questions I have at this point.

Mr. BEGGS. Thank you, sir.

Mr. VOLKMER. The gentleman from Texas, Mr. Andrews.

Mr. ANDREWS. Thank you, Mr. Chairman.

I wonder if you would comment on the relative priority in your mind of the fifth shuttle orbiter and initiating the space station.

If you had to fix priorities, how would you go about it?

Mr. BEGGS. Well, I am on record as saying that I consider the next highest priority after bringing the shuttle to full operational capability to be a permanent facility—a space station.

Of course, within that is the issue of the fifth orbiter. We argued this issue extensively last fall. We came to the conclusion, which I believe still stands because, as I said earlier, we have no change in the market projections that we made last fall, that the market projection could be met with four orbiters. But, we did have the problem that if we laid one up for any reason, either by accident, or for any other reason, modification and so forth, that we might have to repair, or we might conceivably have to assemble a fifth one.

So we did go forward and ask this committee for authorization and funding to purchase structural spares which could be either assembled into a fifth orbiter or be used for repair purposes. Nothing has changed since that decision was made. With an abundance of caution, it might be desirable to have a fifth orbiter. But you cannot justify that on a demand basis.

I have been asked before, and I will freely acknowledge, that systems of this type tend to create demand depending on the service you are to provide. And so it is conceivable that as we start to fly a lot, and we are beginning to fly a lot, that the demand curve will increase dramatically. We have not seen that yet. We will be flying next year maybe eight or nine times. And the following year somewhere in the vicinity of a dozen times or maybe more. So we will be beginning to be able to offer service almost on a demand basis. Which is to say that we should be able to handle payloads that come along on a fairly routine and quick response time.

One of the problems that much of our customer base has cited from time to time is that they are not really going to believe us until we prove to them that we can fly on schedule and that we can meet their requirements in a relatively short period of time. That is to say, short in this business is a couple of years. Now that we are beginning to demonstrate it, maybe that demand will start to increase. But as I said before, we haven't seen that yet.

Mr. ANDREWS. On another point, in the next 5 years what do you think the effect on maybe the overall economy or the program will have on employment on the different centers around the country?

Mr. BEGGS. Well, there will be the usual shifts of ceilings between the centers. I don't anticipate that they will be large in total. That is to say, I think we have typically, over the years, shifted a few hundred people from one place to another in order to cover program contingencies and needs. But, I do not see any major change in employment at the various centers. You have got to remember that the direct NASA employment is 21,000, still relatively low, as it has always been in this Agency's development to the supporting contractor structure. I would guess we still have a 120,000 or so contractor personnel working on the program.

The major impacts of program shifts usually are in the contractor structure, as opposed to the NASA structure because the NASA organization has been kept small. And I hope lean and mean, as we

are primarily in the business of the conceptual design of new programs and the management of the ongoing programs.

Mr. ANDREWS. Thank you, Mr. Chairman.

Mr. VOLKMER. The gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. Beggs, as I look over the goals that you outlined here, that you say are in the process of evolution, but can be expressed in the way that you did in your statement.

I notice here that you say: "continue to explore the requirements, operational concepts, and technology associated with permanent space facilities."

Now I know we are going to go into the space station later on. That would not seem though to imply in your statement that we are in any way ready to move toward an actual space station kind of project. But rather are simply going to continue the research.

Is that just the case of your waiting to talk about that at a later day, or can we infer from what you are saying there that the next 5 years probably will not see a project of that type?

Mr. BEGGS. No, I don't think we intend to imply that there won't be a project. But it does say that our approach to that project will be one of very careful concept definition and concept design before we commit to hardware.

We have learned quite a lot in the last 20 years on how to design and develop major projects. The Hearth report outlined some very sound principles and we are trying to proceed on the space station in light of those principles.

In the case of the space station, it is a very complex system. It is different, as I am sure John Hodge will discuss with this committee, in its basic concept. That is to say, it is not a flying machine as the shuttle is. It's a facility, as a research facility appears. And so it is a little bit different than what we have been doing in this Agency. We want to be very careful that we have studied fully the implications of that. And that we have defined it, and developed the concept in such a way that when we do commit to hardware we will not require any backing and filling. And I think given that kind of a concept that we can better budget for it. And make sure that we come close to sticking to the budget that we submit to you.

And that's what we are really trying to do in pursuing that goal. I think we have had a good study for the last year. It has highlighted a lot of the problems. But that's where we are. We know the problems. Now we need to go on to define the system that we want to design, as we have described it, to develop the architecture, which is, I think, a good word for this thing.

It's architecture rather than anything else—to define the architecture carefully. And then commit to hardware.

Mr. WALKER. But is that a 5-year project? In other words, you are talking 5 years of architectural drawings?

Mr. BEGGS. That particular job is probably a 2 to 3 year project.

I think if we were to make a commitment to go forward with the program, we would take the next 2 years or so in doing that, and then commit to the hardware in the third year. Which would require, of course, that we, assuming we will do this as we always do with the industry, we would solicit the industry in the second year to get them under contract in the third. Because I regret to say, it

now takes us a full year, and sometimes longer, to get a contractor under contract.

Mr. WALKER. The other area that I am interested in out of those goals that you express, is you say: "expand opportunities for U.S. private sector investment and involvement in civil space and space related activities." I get confused at times just what we mean by that. But let me deal with some specifics.

Does that mean that we are anticipating wrapping up some agreements, for instance, with private industry for use of the shuttle in their—in, for instance, supplying unmanned space stations that they might put into place? Is that the sort of thing?

Mr. BEGGS. Yes. That's one area we are pursuing with platforms that can be used on a lease basis or a rental basis for the industry. And there are two or three proposals around of that type. It also, of course, includes a continuing use of the shuttle as a research vehicle in and of itself. We had a number of inquiries and proposals along those lines. It includes the expendable launch vehicles which were discussed earlier. It includes a lot of activities which are in essence service activities surrounding the shuttle system itself—preparing payloads, working at the interface to make it easy for nonaerospace companies to have their payloads integrated in the shuttle.

There are numerous proposals around that just deal with that kind of activity; that is, facilitating the use of the NASA systems, which I think can be very valuable, and can result in some new industries—new companies.

Mr. WALKER. But my perspective, of course, what I think is absolutely essential, is that we have an aggressive program toward the commercial activity and outer space. And that it be something which is a high priority, but is pursued with a very, very aggressive agenda.

I must say that I get discouraged, not from your standpoint, but somewhat here in the Congress when we reach out with aggressive types of proposals only to find Congress throwing roadblocks in the way of some of those things. And I am sure you find some of those frustrations at times too.

But I guess my question was predicated on, where are we going in terms of aggressive programs for commercial space activities?

Mr. BEGGS. Well, I regret to say we sometimes throw our own roadblocks in the way of some of those proposals. But we are trying to change our thought processes. We are trying to change our minds onto the things that we will allow the private sector to come in and do. It does require a little bit of change in our way of thinking about those proposals. Because many of them kind of infringe on things that we have normally considered to be the prerogative of NASA and the Government. But we are trying to change our way of looking at these ideas.

And we are getting, I am happy to say, a lot of activity. In some cases really far out entrepreneurial activity, which pleases me. We have got to find a way so that we don't discourage those folks. There are a lot of young men who have grown up in the space age, who are now thinking in terms of what's possible. And they will be the ones who really develop, in my view, the ideas that will bear the most fruit, that will be the most productive and the most prof-

itable in the future. But, in order to accommodate them, we have got to have a system that's flexible enough to allow them to come with us and to open the door. That's going to require a change in lifestyle for us.

Mr. WALKER. We recently had the rather dramatic and visible example of Sally Ride. I am wondering to what extent women are being integrated throughout the NASA organization? And to what extent they are being given promotions that would reflect career enhancement?

Mr. BEGGS. We are trying to improve, but I will allow that our record in the past has not been all that good. As you know, we have eight women currently in the astronaut corps, about 10 percent. We will be taking another dozen or so in this year. And I hope that a substantial number of that group will be women. We are trying to open the technical opportunities in this agency. We do have quite a number of women scientists and engineers in senior positions now in the agency.

We have made progress in promotions this year. And we intend to continue to emphasize the necessity and the desirability of opening all of the areas in NASA to women. We also intend to make sure that they get a fair share at both the promotional opportunities, and in hiring of entry level scientists and engineers. We did do very well on that this year. I think we brought several hundred freshouts into the Agency, and that's a larger number than we have brought in in a number of years. And a fairly high percentage of those were women. I don't have the number on the tip of my tongue, but we can get it for you.

[The material referred to follows:]

In fiscal year 1983, we will bring in approximately 600 "fresh-outs" of which 25 percent or 150 will be women.

So we are making some progress; but when I look around the room when our senior group gets together, it's pretty much an all male group still. But at the level right below, that we do have many women coming up who are very talented and very good. And I think they will take a larger and larger role in the Agency in the coming 4 or 5 years.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you very much, Mr. Beggs.

I want to welcome at this time the chairman of the full committee to the hearing. And we will now proceed.

As I understand it you have other pressing business, and so you may be excused.

Mr. BEGGS. I would appreciate that.

Mr. VOLKMER. I want to thank you. That's quite all right. And I appreciate your taking the time to come over this morning.

Mr. BEGGS. Thank you, sir.

[Questions and answers submitted for the record follow:]

Questions submitted by Chairman Volkmer during the hearing on July 26, 1983, at which Mr. Beggs testified on NASA's five year plan.

QUESTION A-1:

Mr. Beggs, what do you view as NASA's role in expanding opportunities for U.S. private sector investment and involvement?

ANSWER A-1:

There are several aspects of NASA's role. The first is the development of the science and technology which is fundamental to private sector involvement in space. It was, for instance, NASA's early work in the use of a geosynchronous space relay system which led to the communications satellite industry. The McDonnell Douglas Continuous Flow Electrophoresis experiment had its foundation in experiments which were carried on the Apollo and Skylab missions. Even the technology which ultimately provided the basis for SSUS-A and SSUS-D upper stages was started in Government-funded programs. The area in which NASA has a role is that of helping to provide the opportunities for the private sector to gain access into space and, once there, to effectively and economically use space as a resource for commercial ventures. There are expanded opportunities now with the advent of the Shuttle, and we foresee further expansion in the future through the development and operation of space platforms and other advanced systems. NASA will continue to have a role in the development of those capabilities which are beyond the development opportunities of the private sector or those capabilities which are required for the Federal Government to carry out its broader role in space. The third area which I believe NASA has a role in is that of turning over to private sector the operation of systems which have been developed by the Federal Government. We are doing this today and encouraging the private sector in the management of expendable launch vehicle operations, and I believe that the time may come when the management of Shuttle operations can be effectively taken over by the private sector.

QUESTION A-2:

One of the Agency goals which you stated is: "Conduct effective and productive space applications and technology programs which contribute materially toward U.S. leadership and security."

a. Where does achievement of this goal rank in terms of overall Agency priorities?

b. What is your view of the Agency's role in developing space applications technology for national security objectives?

ANSWER A-2:

a. Each of the eight Agency goals listed in the NASA Administrator's testimony represents NASA's commitment to a high priority aspect of the Nation's space and aeronautics endeavor as expressed in Administration policy statements of the past year. The different goals address differing, and not easily comparable, elements of those national policies. The goal on space applications and technology programs bears on important issue of technological leadership, economic benefits, and national security; its achievement will contribute to expanded commercialization of space. Within the context of the NASA responsibilities as established in the Space Act and as reinforced by the Space Policy Statement of July 4, 1982, it is not possible to establish an absolute priority ranking among the broad categories of NASA's space activities.

b. NASA has a long history of cooperation and sharing in the development of technology with the national security community, ranging from joint use of the Shuttle to our traditional role in aeronautics, both civil and military. Sometimes the principal benefit goes in one direction, sometimes the other. Outside of our special status in aeronautics, we do not develop technology specifically to satisfy national security needs. We do cooperate fully in sharing what we develop for a variety of civil purposes in those cases where there is also a national security objective that can be served by the same technology.

QUESTION A-3:

With regard to space applications activities the Agency appears to continue to have a keen interest in advanced sensor development.

What is your view of the Agency's role in conducting user development activities including application systems verification tests and technology transfer efforts?

ANSWER A-3:

Our earth science and application activities are focused on the utilization of space-borne instrumentation to study the processes of change

occurring on Earth, to establish cause and effect relationships, and to develop computer-based models which closely simulate the dynamics of the actual system. In performing these research activities, we are involved in acquiring data from state-of-the-art remote sensing instrumentation and in generating algorithms for the manipulation of that data into information which is applicable to our needs. We have recognized that, in fulfilling our research objectives, other uses of our data and methodologies will be identified that may have application in the private sector and/or other sectors of government. We, therefore, have a policy of open exchange of our experience with all potential users and provide access to these technologies by a variety of mechanisms. In cases where joint activities between NASA and other elements ar appropriate, NASA is receptive to those which contribute to the overall furtherance of Agency objectives and do not conflict with our ability to perform our own research and development tasks.

QUESTION A-4:

What is NASA doing to provide a better organizational focus for commercialization activities?

ANSWER A-4:

This past spring, we asked that National Academy of Public Administration (NAPA) to examine the overall question of NASA's role in the commercialization of space. The results of that study led me to set up an internal task force with the responsibility to develop the policies and procedures which would govern NASA's involvement in private sector commercialization and would provide guidance on possible organizational steps which should be taken to carry out those policies. This task force is to complete its work late this year, and we will report to the Congress on its results as soon as I have had an opportunity to review them and to determine what follow-on steps are needed.

QUESTION A-5:

One of the stated Agency goals is to "establish NASA as a leader in the development and application of advanced technology and management practices which contribute to significant increases in both Agency and national productivity."

Could you elaborate on what specific activities are underway to achieve this goal?

ANSWER A-5:

NASA has established a Productivity Improvement and Quality Enhancement program to improve NASA operations, make NASA a model for other Government organizations, and to impact national productivity. The brand based program is best described in a seven task focus know as **HEIGHTEN**. The first task is Heightening management and employee knowledge and awareness. Second, Encouraging greater participation in management decision-making. Next, Identify impediments as well as opportunities for greater productivity. Also, Getting contractor/NASA team involvement in Higher productivity contractor approaches. Next, Trying out new management practices and using new technology, Evolving productivity trend analysis (productivity measures) and last, Noting, rewarding and diffusing successful approaches through the organization. One example of a specific activity is in the area of Encouraging employee participation through NASA Employee Teams (NETS, but most often called Quality Circles). These NETS will be operational at every agency installation by October, 1983.

QUESTION A-6:

Do you believe that encouraging the commercialization of expendable launch vehicles is counterproductive to achieving the most cost-effective Space Shuttle program?

ANSWER A-6:

I do not believe that encouraging the commercialization of expendable launch vehicles (ELV) is counterproductive to achieving the most cost-effective Space Shuttle program when considered within the context of the President's policy statement. That policy statement on commercialization of expendable launch systems reaffirms the national commitment to the Space Transportation System (STS), affirms the existing Shuttle pricing policies, and establishes the framework within which commercial expendable launch systems must operate. The STS will continue to be the mainstay of this Nation's space program as it evolves to support and foster national security and civil programs. NASA is, therefore, committed to making the STS fully operational and cost effective in providing routine access to space.

The existence of competitive systems can provide an additional stimulus to NASA in achieving cost effective operations with the STS, and commercial expendable launch vehicles could provide a U.S. alternative launch capability to commercial and foreign customers unable to be manifested on the STS.

QUESTION A-7:

What success is NASA having in attracting graduate engineers to the Agency?

ANSWER A-7:

NASA is successfully attracting "fresh-out" engineers to the Agency, but we have worked very hard for this success. This year, for example, we sent 70 recruiters to 142 schools and hired close to 600 newly graduated engineers and scientists. Although we project our staffing needs to continue at this or higher levels, we expect recruiting to be more difficult as private sector competition intensified with improving economic conditions.

QUESTION A-8:

What success is NASA having in attracting senior industry officials to senior NASA positions?

ANSWER A-8:

An attractive salary is key to the recruitment of executive talent; even though there have been recent increases in Federal Executive pay, the Government is just not competitive with private sector pay for top-level executive talent.

Over the past five years NASA has, on several occasions, been interested in individuals who represent the very best in their fields only to find that the Federal salary was too great a hurdle in the negotiations. Key executives with national reputations often commend total compensation packages three to four time what we can pay. Even when these individuals have been attracted to the challenge of the NASA position, the artificially low pay in Government has forced declinations of our offers.

Another factor that deters some people from taking Government executive positions is the conflict-of-interest laws. An individual with years of successful private sector experience often has a sizable portfolio of investments. In the case of technical managers, these investments tend to be in firms engaged in work associated with NASA's programs. The potential financial loss from divestiture, no doubt, results in executives remaining in the private sector rather than taking Government jobs.

In addition to the problem of attracting talent from outside the Government, we continue to have a difficult situation regarding internal mobility.

Executives from the NASA centers have no economic incentive to move to Washington and other high-cost areas. The combination of the relatively low salary, moving expenses, and the cost of living in those areas result in a loss of real income for executives willing to move there.

QUESTION A-9:

Does the NASA 5-Year Plan being presented envision increased resources for the future?

ANSWER A-9:

Because of the lack of precision in predicting mission and program costs, especially for programs to be initiated five years from now, we have not tried to total the costs associated with the program in our five-year planning. However, our planning is optimistic in terms of the programs we believe should be conducted in order to respond to national policies. We estimate that an increase of about 30- to 40-percent in our budget from the current level would be needed to conduct all of the outlined programs of the plan.

QUESTION A-10:

How do you view the relative priority of procuring a fifth Shuttle orbiter and initiating a Space Station development program?

ANSWER A-10:

We have faced the issue of the relative priority of a fifth Shuttle orbiter and a potential Space Station initiative for the past several years and I believe we are now at a point where those priorities really do not compete.

QUESTION A-11:

Do you foresee a growth in NASA defense related activities?

ANSWER A-11:

Yes, in aeronautics, NASA has, since its inception, had a continuing close relationship with the DOD. In consonance with the Administration's aeronautical and research policy and with NASA's aeronautical goals and objectives, greater collaboration with DOD can be expected.

In space, we can foresee a substantial growth in defense related activities. This stems from the

NASA/DOD relationship on the Space Transportation System and the DOD commitment to the use of the Shuttle for space operations. Further, the President's space policy statement of July, 1982, provided that there will be a strong national security space program, and that there will be close coordination, cooperation and information exchange between the civil and national security programs.

QUESTION A-12:

NASA's materials processing in space activities does not fit very well in the mainstream of Space Science and Applications programs.

Is there a better organizational location for this program in another program office?

ANSWER A-12:

Early microgravity activity by NASA concentrated on materials processing in space. However, it quickly became obvious that advances in space processing could occur only if a sound scientific base existed. For this reason, the materials processing activities have concentrated both on achieving the scientific rationale and on conducting research.

While progress has been made in both areas, NASA believes that this program could be made more effective if the scope of the program were to be expanded. Since the fundamental charter of the program was the scientific and applied uses of space (i.e., low gravity), basic physical and chemical reactions in a microgravity environment were felt to be appropriate areas of investigation. For this reason, title of "Materials Processing in Space" is being changed to "Microgravity Science," and the area has been expanded to include elemental processes in addition to its previous concentration on materials processing. With this redefined emphasis, a Microgravity Science Division, (including materials processing) fits well within the programmatic responsibilities of Space Science and Applications.

Mr. VOLKMER. At this time now we will proceed with the hearing of our second witness.

General Abrahamson, you may proceed with your testimony. And as I understand it we have some Viewgraphs.

STATEMENT OF LT. GEN. JAMES A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT

General ABRAHAMSON. Yes, sir.

It's obviously a pleasure to come back for you, Mr. Chairman, the members of the committee, and Mr. Fuqua from the full committee.

If you don't mind, I would like to move over here so that I could at least refer to the charts.

I will try to talk loudly. So if there is any problem in hearing me, please let me know.

The goals and objectives document, as Mr. Beggs indicated, has one very principal goal for the Space Transportation System. And that's for us to bring the transportation system into a fully operational and cost effective basis as quickly as possible.

OFFICE OF SPACE FLIGHT

BRIEFING OUTLINE

- **INTRODUCTION**
  - GOALS AND OBJECTIVES
- **SPACE TRANSPORTATION SYSTEM: Where are we and where are we going?**
  - SPACE SHUTTLE
  - SPACELAB
  - EXPENDABLE LAUNCH VEHICLES
  - UPPER STAGES
- **ADVANCED PROGRAMS**

Figure 1

That principal goal (figure 1) is, of course, the Agency goal. And that's supported by a series. And, of course, our principal effort right now is in the Space Transportation System. So I will comment briefly. And this will really be a position report for you on where we are and where we are going in the major elements of the Space Transportation System. And then I would like to concentrate on the advanced programs, which talked really about the infra-

structure for both the shuttle and for the space station, as that may well go forward.

OFFICE OF SPACE FLIGHT

OSF OBJECTIVES

- EACH MISSION—SAFE AND SUCCESSFUL
- MAINTAIN OPERATIONAL LAUNCH SCHEDULE
- REDUCE OPERATIONAL COSTS
- COMPLETE STS DEVELOPMENT
- EXPLOIT STS CAPABILITIES

Maintain Space Leadership for the United States

Figure 2

That primary goal for the Agency really has tiered down into this set of goals for the Space Transportation System itself. And if you will notice, the first one (figure 2) is that important one that says that we must be safe and we must be successful on each flight. We maintain that priority in whatever we do, including our budgeting, and, of course, including in the program that we present to you. After that, our next one is to maintain the operational launch schedule. And that's imperative because of the confidence that our customers must have in our ability to perform as we have contracted. And Mr. Beggs mentioned that.

And then we march down into the rest of that. And all of that adds up to, we believe, in the launch vehicle area. But more importantly than just launch vehicles, also in the research area, that it is the key to maintaining space leadership for the United States.

FIRSTS IN 1983

- ◆ 1st FLIGHT OF A NEW ORBITER ("CHALLENGER")
- ◆ 1st USE OF HIGHER PERFORMANCE SSME'S
- ◆ 1st LIGHT WEIGHT EXTERNAL TANK (ET)
- ◆ 1st HIGH PERFORMANCE SOLID ROCKET BOOSTER (SRB'S)
- ◆ 1st ADAPTIVE FIRST STAGE GUIDANCE (IMPROVED PERFORMANCE)
- ◇ 1st SPACELAB MISSION
- ~~1st DEDICATED DOD FLIGHT~~
- ◇ 1st AROUND-THE-CLOCK CREW OPERATIONS
- ◆ 1st PROXIMITY OPERATIONS
- ◆ 1st RMS GRAPPLE OF A FREE-FLYING SATELLITE
- ◇ 1st NIGHT LAUNCH/LANDING
- ◆ 1st USE OF HEADS-UP DISPLAY (HUD)
- ◆ 1st EXTRA-VEHICULAR ACTIVITY (EVA)
- ◆ 1st FIVE-MEMBER CREW (STS—7)

Figure 3

Every so often I'll have a little picture, and I'll comment on that on the side. Earlier in the year, I laid out what were our objectives for this fiscal year. And you will see on (figure 3) a series of those objectives. All of the principal ones are listed there.

The blackened diamonds indicate the ones that we have completed already during the year. If you will notice, of course, we have lost the dedicated DOD flight, which was scheduled for this fall. That was flight No. 10. And that is delayed because of the IUS problem, the upper stage problem that we had. But outside of that, we really only have three main diamonds yet to fill in. Our first spacelab mission—which I will comment more on later—and a night launch and landing. And not shown there, unfortunately—that was left off, we would also have liked to have gone into Kennedy our first time. It was a great disappointment that we weren't able to last time—but we will do that just as soon as we have an opportunity.

NASA National Aeronautics and Space Administration

Headquarters
Washington, D.C.

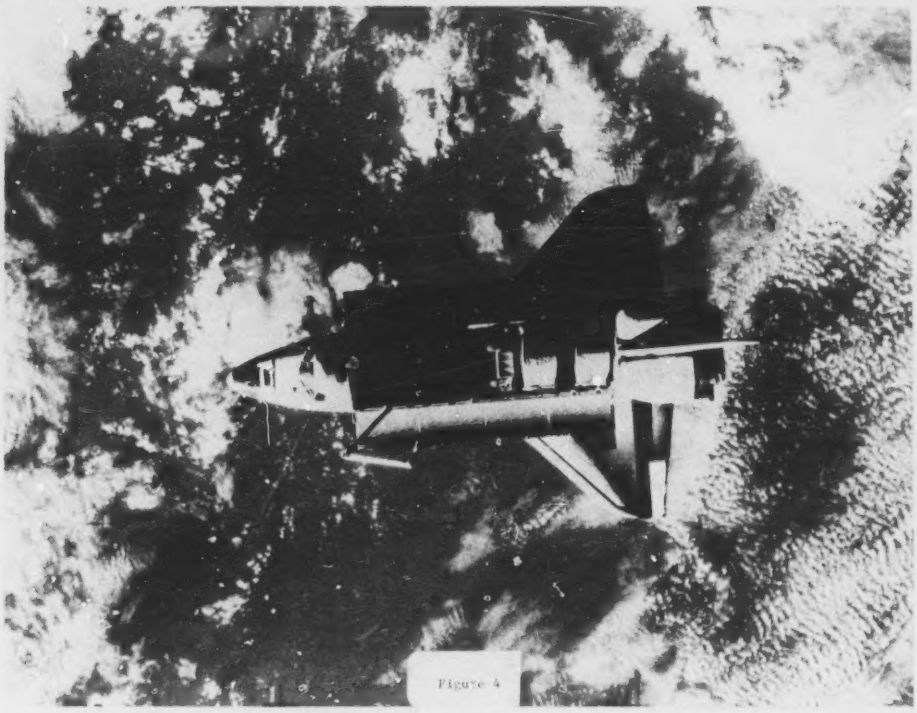


Figure 4

This was, of course, the picture (figure 4) that I think just about everybody now knows. It's a lovely picture of the space shuttle taken from the small German satellite SPAS, which I believe represents just exactly where space technology can go. And that's what the shuttle opens up for the system—that's important. Not only that it takes pictures of the shuttle, or performs experiments, but it's a pathfinder for both United States and European, and all of the free world's industry, in my judgment. OK. But the shuttle itself is doing well as we look at it at NASA. And I will talk about just the main elements of the shuttle.

SOLID ROCKET BOOSTER

CURRENT STATUS

- SUCCESSFUL COMPLETION OF FIRST 7 LAUNCHES
  - FIRST LIGHTWEIGHT SOLID ROCKET MOTOR USED ON STS–6
- HIGH PERFORMANCE MOTOR (HPM) FULLY QUALIFIED (3000 lb GAIN)
- 10 BOOSTER FORWARD ASSEMBLIES/AFT SKIRTS IN ASSEMBLY/REFURBISHMENT
- RECOMPETITION FOR SRB FORWARD AND AFT SKIRT REFURBISHMENT/ ASSEMBLY/CHECKOUT IN PROCESS
- FILAMENT WOUND CASE (FWC) DEVELOPMENT UNDERWAY (5500 lb GAIN)

FUTURE PLANS

- FIRST HPM FLIGHT SCHEDULED FOR STS–8
- PRODUCTION RATE INCREASE TO 24 FLTS/YEAR BY FY 1987
- COMPLETE FWC STATIC FIRINGS/DEVELOPMENT PROGRAM
- FIRST FILAMENT WOUND CASE MOTOR FLIGHT IN OCTOBER 1985
- CONTINUE PRODUCIBILITY IMPROVEMENTS
- ACTIVATE NEW REFURBISHMENT SUBASSEMBLY FACILITY FOR BOOSTER ASSEMBLY AND CHECKOUT

Figure 5

And starting with the solid rocket booster (figure 5), we have, of course, completed now seven successful launches. And we fired a lightweight version of the solid rocket booster on No. 6. We have now qualified a high performance motor which will give us additional capability. And we have some 10 boosters that are now in various stages of refurbishment. And what that means, is on every shuttle launch now we have a mixture of used hardware. If you were going to paint each one a different color from the launches ahead of it, it would look like a rainbow as we go ahead.

So, the concept of repair and refurbishment for the solid rocket booster, I think, has been well established. Our challenge now is to bring the price down for that operation. One of the ways that we are doing that, is we are going out to recompete the solid rocket booster refurbishment activity. The decision to place that at Cape Kennedy was made. And part of that overall proposal is looking at the proper facilities, as well as improved manufacturing techniques and concepts. And that is proceeding. And we do expect an RFP to be out this fall. Meanwhile, we have had an initial assessment period for interested contractors. And there are a number of interested contractors.

The filament wound case development is well under way. And that is required for NASA for our Galileo and our ISPM missions in the early part of 1986. It's also required for the Department of Defense heavyweight mission. And so our time scale for that development is for October 1985 in order to give us a little margin. And that is the first launch that's scheduled now from Vandenberg.

And by the way, I was at Vandenberg just 2 weeks ago. And that is progressing just very, very well at this point. And it's not only the facilities and the equipment that's now coming in, but you can feel kind of a pace amongst the project officers. They know that it's real. And they know that they have a fighting chance of making that. And you can really see a difference. There are some very fine facilities that are coming on line. And they will be used not only by the Department of Defense, but also by NASA and some of our commercial customers.

For the future, we will fly our high performance motor on STS-8—when we set that official launch date.

Mr. VOLKMER. How does that vary from August 20?

General ABRAHAMSON. Sir, we could make August 20 early. And we can make it quite easily from the shuttle viewpoint. But, there is a relationship between the ninth launch, the spacelab launch, and our ability to do some highly desirable tests with the TDRSS. Therefore, the reason that we are not announcing that official date, is that we are holding up and watching the progress that the TDRSS satellite is making, and trying to optimize that.

My judgment is that the 20th is the earliest date, now that we have planned for it this way. And that it shouldn't be much more than a week or so after that. But we would only make that week slip if indeed we gain a significant advantage for the ninth launch if we proceed.

We can see the production rate increasing properly by fiscal 1987. And that's to meet our 1988 goal that says we should be able to handle 24 launches per year. So we think that's all very effective.

The static firings and development program for the filament wound case is well under way. And we had teams out at Hercules and at Thiokol last week, and there are a large number of those items that are in manufacture coming off the line now. So that's very encouraging.

EXTERNAL TANK

PRESENT STATUS

- DEVELOPMENT COMPLETE
- 10 FLIGHT TANKS DELIVERED
- 7 TANKS SUCCESSFULLY FLOWN
- 12 TANKS IN PRODUCTION FLOW
- LIGHTWEIGHT TANK ~10,000 lbs REDUCTION (13%) — FLEW ON STS–6
- PRODUCTION BUILDUP TO 24 PER YEAR UNDERWAY

FUTURE PLANS

- CONTINUE PROGRAM COST REDUCTION/PRODUCT IMPROVEMENT ACTIVITY
  - IMPROVED THERMAL PROTECTION MATERIALS
  - ROBOTICS
  - INCENTIVE CONTRACTS
- POTENTIAL ORBITAL UTILIZATION
  - PLATFORM COMPONENTS
  - AFT CARGO CARRIER

Figure 6

In terms of the external tank (figure 6), we consider the development complete. And, indeed, this is the bright spot of the entire program. We have 10 of those flight tanks delivered. We have flown the seven that I show. There are 12 that are in the final assembly portion of the production flow itself. And we have now demonstrated on six that lightweight tank, which is a very important milestone for us. And on the last flight we flew the last of the heavyweight tanks.

In fact, one of the changes in going to the lightweight tank was to improve the ice situation. So we did get more damage through the orbiter from, we believe, ice, on the last flight as we flew out the last of the heavyweight tanks. But we don't expect to see that particular problem again.

We have a program well underway to reduce the thermal protection system. That will bring down the cost as well as improve our weight and performance. But more important, combined with that is an extensive program for introducing robotics, and as part of an incentive contract, to bring the cost down. And since that's the only real throw away element of the system, that's very imperative that we do that. We are studying, in the future, looking at the lightweight tank either as an optional part of a space platform—as a structural element. And that potential has been outlined in several of our studies. In addition, there is a way in which we can tack on into the open area under the tank a fairly large cargo-carrying capacity. And we are looking at that as a potential to take up an orbital transfer vehicle of certain kinds of designs. Now these are only possibility studies at this point. But they do show that we are trying to exploit all of the elements in this system.

27-459 O—83——3

SPACE SHUTTLE MAIN ENGINE

CURRENT STATUS

- EIGHT FLIGHT ENGINES DELIVERED
  - FOUR RATED POWER LEVEL CONFIGURATION
  - FOUR FULL POWER LEVEL (FPL) CONFIGURATION
- FPL ENGINE CERTIFIED FOR TEN FLIGHTS
- BIGGEST PROBLEM HIGH PRESSURE PUMPS
  - HIGH MAINTENANCE
  - SHORT SUPPLY
- CURRENT DEVELOPMENT EFFORTS TARGETING PUMP PROBLEM
- LIFE CERTIFICATION EXTENTION TO 55—MISSION USE IN PROGRESS

FUTURE PLANS

- DEVELOPMENT OF IMPROVED HIGH PRESSURE PUMPS
- SPARES AUGMENTATION
- ADVANCED DEVELOPMENT BEING ASSESSED
  - GREATER DURABILITY/LONGER LIFE
  - REDUCE MAINTENANCE
  - HIGHER THRUST

Figure 7

The shuttle's main engine (figure 7) is probably the most difficult of all our development effort. We now have eight flight engines that are delivered and fully accepted, and are acceptable to operate at 104 percent. The engine has been certified at that 104 percent for 10 full flights without maintenance with the exception of the pumps. And I will come back to the pumps. That was our initial goal. We do have an ongoing program which will extend that out to our goal of 25, and then later on 55 full flights with that engine. Now, please notice that we are limiting it to 104 percent. And we are limiting it because just like an airline that doesn't have many parts at this point in time, we can't afford the engine to get chewed up at the high power levels that one could operate the engine at.

We have completed what we consider to be a satisfactory certification at a 109 percent. So that's available to us if we need it. And the places that we will need it are on certain DOD missions, and also on the Galileo, and about 107 percent on the ISPM missions. So that's ready and waiting anytime we wish to use it. So that's an operational limit at 104 percent. However, the pumps do need to be replaced and turned around about every third flight. And that is really our most serious maintenance problem as we look at the program. Therefore, we are defining a program to improve those pumps—which you will see in the fall, or in the spring rather during the budget cycle—and that is to try to, in fact, to improve the maintenance operation of the engine itself.

We are also looking at a more extensive program to give us higher confidence to be able to operate at a 109 percent, and for stages to perhaps go above that. But those are in definition at this point in time.

ORBITER

CURRENT STATUS

- COLUMBIA – PREPARATIONS FOR SPACELAB 1 ON STS–9
- CHALLENGER – PREPARATIONS FOR STS–8
- DISCOVERY – SCHEDULED FOR SEP 1983 DELIVERY
- ATLANTIS – SCHEDULED FOR DEC 1984 DELIVERY
- STRUCTURAL SPARES – AUTHORIZED IN CURRENT BUDGET

FUTURE PLANS

- RE-EXAMINE REQUIREMENTS FOR 5th ORBITER
- EVALUATING MINIMAL IMPROVEMENTS FOR OPERATIONS, RELIABILITY AND MAINTAINABILITY

Figure 8

NASA National Aeronautics and Space Administration

Headquarters
Washington, D.C.

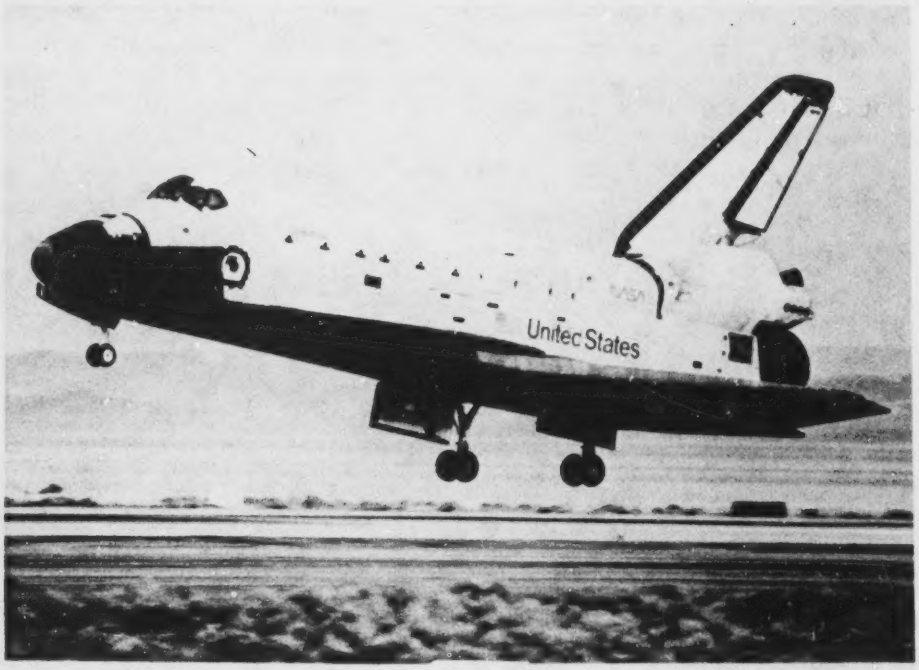


Figure 9

The orbiter (figures 8 and 9) is the Columbia—which is now tried and true, and a real favorite of all of us—is in a flow for the spacelab for the September launch. And we could easily make that—flow is coming very well—the Spacelab as well as the orbiter modification—so we could easily make that September launch from the orbiter viewpoint. Again it's the problem of the TDRSS and using the TDRSS in our simulations to insure that we have high confidence in being able to complete that mission satisfactorily. That is the problem.

The Challenger is in preparation for STS-8. And notice with the loss of STS-10, we will then have a period that will be down. We think that that has some benefits, in fact, because we are looking forward to the shuttle processing contract being able to have a little breathing time in terms of their initial operations in the fall at the Cape.

The Discovery is on schedule for September, 1983, delivery. And in fact, looking very, very good. It's a little early to say that the Atlantis will not have any problems between now and December of 1984. But at this point it looks very good. So we think that the orbiter production program is on schedule.

Of course, the President approved—and Mr. Beggs mentioned it—due to the lack of being able to firmly predict a demand that exceeds our present four orbiter fleet, we approved and you approved, a structural spares program. That is now in implementation. And we are reexamining the requirements for that fifth orbiter with our manifest needs as well as our projection of turn around time and maintenance requirements. We are reexamining that on a periodic basis. Actually about every 6 months or so. So that decision could be made on a national basis when it it clearly needed.

Outside of that, we are trying to keep changes to a minimum on the basic orbiter program. And so there are very few improvements that are being offered. Although some are necessary to improve the orbiters for long term-operations.

NSTS RESERVATIONS STATUS REPORT

	PAYLOADS	EQUIV FLTS
RESERVATIONS ON 12/31/82	**175**	**71**
DOD	(40)	20½
NASA	(50)	22¾
FOREIGN & COMMERCIAL	(85)	27¾
ADDITIONS SINCE 1/1/83	**37**	**17¼**
DOD	(5)	5
NASA	(15)	7½
FOREIGN & COMMERCIAL	(17)	4½
TOTAL	**212**	**88¼**
DOD	(45)	25½
NASA	(65)	30¼
FOREIGN & COMMERCIAL	(102)	32

Figure 10

Here (figure 10) is our reservation status report. Essentially I'd like to go back to Dec. 31, 1982 because that's when we really had the first of our engine problems; and, we continued to bring people on even in the face of that engine problem. Your charts are out of date. That showed some less than 212 total. We now have additional foreign and commercial customers that have been signed up. Three of the most notable last ones were a new satellite project by Fordsat—the Ford Corp. Now, some of these are double booked. And we may not be able, in fact, to fly every one of these. And that's a very tough assessment that we have to work as we go ahead. But that is a full manifest out. With the exception of some refly opportunities, we are filling in that manifest out through 1987. And as Mr. Beggs indicated, beginning to go into 1988.

WHERE WE ARE GOING

- REVOLUTION IN SPACE OPERATIONS HAS ALREADY BEGUN
  - REUSABLE VEHICLES
  - MULTI PAYLOAD CAPABILITY
  - LOWER COST OPERATIONS
  - SIMPLIFIED OPERATIONS
- WHERE WE ARE GOING (NEAR TERM)
  - SPACECRAFT REPAIR
  - SPACECRAFT REFUELING
  - PAYLOAD CHANGING
- WHERE WE ARE GOING (FAR TERM)
  - SIGNIFICANT NEW MISSIONS
  - REDUCED COST OF SPACE SYSTEMS

Figure 11

I have talked about this before to this committee. And I think revolution is well underway. Here are some of the things that we are now interested in addressing in terms of the near term so that we will be ready for the full revolution when it comes. And as we look at some of the advanced programs, (figure 11) I'll talk about some of that.

In the far term, of course, we are looking at reduced costs and significant new missions.

SPACELAB

FLEXIBLE SCIENCE/APPLICATIONS LABORATORY

- ESA/NASA COOPERATIVE INITIATIVE

STATUS

- FIRST VERIFICATION MISSION LAUNCH SEPTEMBER 1983
- SECOND VERIFICATION MISSION MARCH 1985 (SL–2, PALLET–ONLY/IPS)
- FIRST OPERATIONAL MISSION SEPTEMBER 1984 (SL–3)
- FIRST REIMBURSABLE SPACELAB FLIGHT JUNE 1985 (GERMAN D–1)

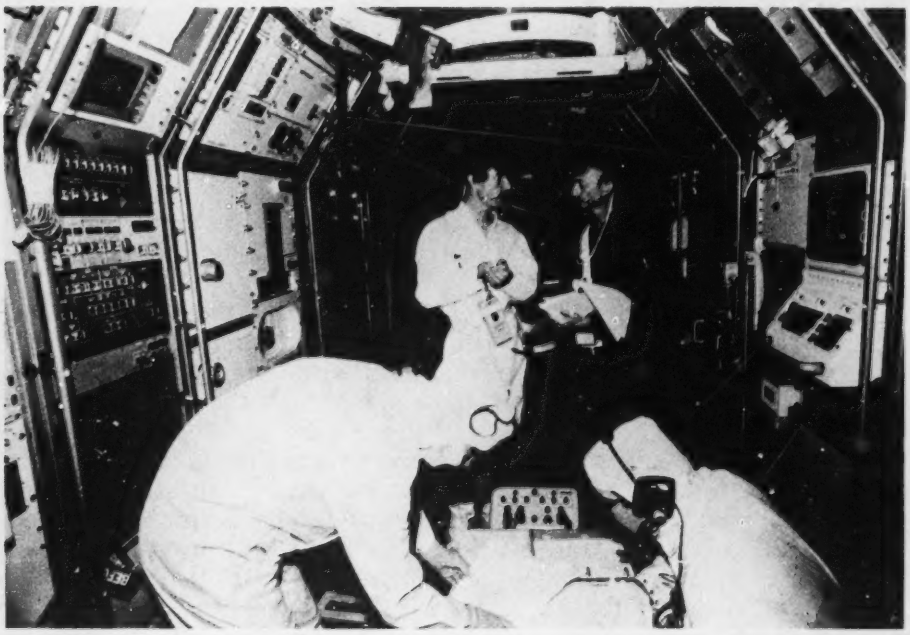
PLANS

- EXAMINING EXTENDED MISSIONS
- QUICK ACCESS FOR USER
- REDUCED OPERATING COSTS

Figure 12

NASA National Aeronautics and Space Administration

Headquarters
Washington, D.C.



The Spacelab (figures 12 and 13) is a transition element in this entire portion of the program. Here is a view inside of the spacelab as we are looking ahead to STS–9. Of course, that will be our first six person crew. That will be our first European astronaut that will fly with us. And in any case, that is moving out just very, very well in both the modification of the orbiter and in the final testout of the spacelab itself. Please notice that in addition to these verification flights and our first operational mission, we now have our first reimbursable mission that has been signed up with the Germans. And the Japanese are negotiating with us for a mission for some of their interests as we go ahead.

EXPENDABLE LAUNCH VEHICLES

DELTA

- FIRM LAUNCH REQUIREMENTS THROUGH MISSION NO. 179
- FINISH PRODUCTION AND DELIVERY OF 11 VEHICLES (THRU NO. 181) BY 4th QUARTER FY 1984

ATLAS–CENTAUR

- LOW PRODUCTION/LAUNCH RATE – ALL REIMBURSABLE (INTELSAT, NAVY)
- FUTURE LAUNCHES INCLUDE INTELSAT V–A (ON 5/83, 12/83, 2/84, 6/84, AND IN 4QCY 84), AND FLTSATCOM (IN 3Q85, 3Q86, 2Q87)
- NO FURTHER IMPROVEMENTS OR GROWTH ARE CONTEMPLATED AT THIS TIME

ATLAS–F

- CONTINUE CURRENT SUPPORT THROUGH CY 1987

ATLAS–H

- CONTINUE EXISTING PROCUREMENT OF VEHICLES FOR USAF

SCOUT

- OPERATIONAL – 15 PLANNED LAUNCHES THROUGH 1987 UNDER NASA MANAGEMENT

Figure 14

Now expendables (figure 14)—and this really comes to the question of the transition period that was asked earlier. If you will notice, we have closed off our production and delivery with No. 181. However, that delivery will not take place until the fourth quarter of 1984. Therefore, there is time for, we believe, for a commercial enterprise to come in and pick up that production in a reasonably graceful way—and the same thing with Atlas-Centaur—in fact, that's much better in that that goes well out, in terms of operations, well into 1987, and we do have an ongoing production line there as we go ahead, too. As you can see, Atlas-F also goes out to 1987-88, on a continued basis, for the U.S. Air Force, for a period of time. And we still operate some Scout launches out of Wallops Island, and we have about 15 of those scheduled, and the majority of those are scheduled for the U.S. Navy.

Here is when we begin to now see the important partnership between the commercial program and the NASA program.

UPPER STAGES

INERTIAL UPPER STAGE (IUS)

- CONFIGURATION FOR TDRSS
- ANOMALY EXPERIENCED ON STS–6/TDRSS FLIGHT

PAYLOAD ASSIST MODULE (PAM)

- PAM–D COMMERCIAL DEVELOPMENT COMPLETED AND NOW OPERATIONAL
- PAM–DII COMMERCIAL DEVELOPMENT UNDERWAY, WITH NO NASA TECHNICAL INVOLVEMENT
- PAM–A DEVELOPMENT UNDERWAY

CENTAUR

- A 19.5 ft STAGE DESIGNATED CENTAUR G BEING DEVELOPED TO MEET JOINT AIR FORCE/NASA REQUIREMENTS
- A STRETCHED VERSION (29.1 ft), DESIGNATED CENTAUR G PRIME, BEING DEVELOPED FOR THE GALILEO AND INTERNATIONAL SOLAR POLAR (ISPM) MISSIONS
- CENTAUR G TO BE OPERATIONAL BY MID–1987, PLANNED FOR VENUS RADAR MAPPER MISSION IN 1988

TRANSFER ORBITAL STAGE (TOS)

- A NASA/OSC AGREEMENT FOR THE COMMERCIAL DEVELOPMENT OF TOS WAS SIGNED ON APRIL 18, 1983
- OPERATIONAL CAPABILITY NO LATER THAN DECEMBER 1987

Figure 15

The inertial upper stage (figure 15), of course, is in that anomaly investigation phase. The formal investigation board has completed its work. It's indicated that one of the seals is the fundamental problem, and they are proceeding with an experimental and quality improvement program, which hopefully, will be ready for a launch in the spring. Now, we are trying to be as flexible in our response to that as possible. We see that the first operational mission that could support an IUS and a TDRSS launch would be the 12th mission. We are looking for additional flexibility in the spring by looking at whether or not it makes sense to flip our Solar Max Mission, and that 12th mission, and give a little additional time.

The DOD mission or a TDRSS could go on the 15th mission which is in July, and we have another NASA opening in our manifest later on during the year, so we have three opportunities. And I believe that we will be able to recover, without any significant impact, on our commercial customers in the year 1984, provided, of course, the IUS makes the progress that we all hope. But that is an important issue, whether or not it does it.

The Payload Assist Module, PAM-D and PAM-DII, is the first of those important partnerships, and I would emphasize that there is more money that is being spent on commercial entrepreneurial activities in conjunction with the shuttle than there is in terms of the expendable launch vehicle proposals that people talk about. These

are quite real, you know, and this one, of course, is now on four satellites, and we are delighted with that.

The PAM-A is the one that is the most questionable. We don't really have a use for that so we are now reevaluating where we are in the PAM-A program and whether or not it makes sense to finish that or how many vehicles it makes sense to complete. The Centaur is under development now to meet those dates and that development is a very aggressive one managed out of the Lewis Research, or out of the Lewis, and we doing, we think, effectively to stay within costs as well as meet those goals

Here is the next of our commercial enterprises. This is the TOS or as we call it the transfer orbital stage. That agreement has been signed and they are now aggressively producing a commercial stage which fills in between the PAM-D and the Centaur and we are just delighted with that particular enterprise. In fact, they took one of our best NASA people now to come out and begin to prepare their programs. I am not sure that I agree with that but it does look like that will be accomplished.

COMMERCIAL PROPOSALS

ELV'S

- TITAN 34D
- ATLAS CENTAUR
- DELTA
- NEW ELV'S (UNDER DEVELOPMENT)

STS

- MANUFACTURING/MATERIALS PROCESSING
- PLATFORMS FOR LEASE (INCLUDING FREE FLYER)
- TRANSFER ORBIT STAGE
- 5th ORBITER
- PAYLOAD PROCESSING
- OTHERS

Figure 16

I mentioned the commercial proposals (figure 16), talking about Atlas and Delta, and those, of course, are the NASA's proposals. The Martin Corporation, and FEDEX, (Federal Express) as well as the Space Transportation Corporation have been in discussion with the Air Force on the Titian version and its commercial enterprise there. I think that is under some reevaluation at this point. There

are also, at least two new expendable launch vehicles that are under development.

One is the Conestoga by SSI with potential launching either in Mississippi or in Texas, or in Hawaii. And then what was formally the ARC Technology and they have now renamed themselves Starstruck. I love that name. They are proposing a booster of about the size of the Scout to be launched at sea, and perhaps off the, in Pacific at some point. And by the way, they are looking for an initial launch sometime this fall. Now that particular one is the only one that has applied for a license, remember the Conestoga has already cleared a license, under the new interim procedure and we think that that is going quite well in terms of processing that license. That was a matter of concern by this committee earlier.

We talked about the concern that the commercial program could go ahead. Those are some examples of areas where we are discussing joint endeavor agreements or other commercial arrangements with the various people and I would just like to point out that many of these range from, of course, McDonnell Douglas and several other versions of materials processing down to very small instrument units that would provide telemetry data on the atmosphere and environment inside the orbiter when a commercial payload or a scientific payload goes and that is very helpful to the commercial people in term of insurance.

So there are those kinds of small fittings all the way up to the fifth orbiter discussion. I will give you just a brief position report on fifth orbiter. The last written proposal that we had from the Space Transportation Co. was on April 27. and that was a statement of principals which was in response to a series of discussion items that we had had. The last formal meeting that we had with them was on the June 10, and we have had several informal meetings and I believe they are now in a re-evaluation position in terms of their corporation.

But you can see that we have a whole range of commercial endeavors that we are working very hard to accommodate and to encourage and to make them part of the infrastructure from items on the ground all the way up to supporting the shuttle and the ELV's themselves.

ADVANCED PROGRAMS THRUSTS

- SATELLITE SERVICES
- ADVANCED TRANSPORTATION
- UNMANNED PLATFORMS
- MANNED FACILITIES
  - SPACE STATION (TASK FORCE)
  - CREW AND LIFE SUPPORT SYSTEMS

Figure 17

Here are the objectives (figures 17) for the advanced programs. I will just briefly run through some examples of the things that you are looking at here

SATELLITE SERVICES OBJECTIVES

- SATELLITE PLACEMENT AND RETRIEVAL
- REFUELING AND SERVICING AT ORBITER
- REFUELING AND SERVICING REMOTE FROM ORBITER
- DEBRIS REMOVAL
- CONSTRUCTION AND ASSEMBLY
- DEVELOPING SPACE-BASED CAPABILITY

Figure 18

Here are the objectives (figure 18) of a satellite services program. This is to refuel the satellite that has expended its fuel and therefore is useless for anything else. A good example of a satellite, and I am going to be brief now, is the first India communications satellite that is sitting there. A dead satellite that cost the Government

of India and the insurance community around the world a great deal of money.

So here are our objectives, and I may have a picture of the—here it is—I am sorry. I would like to just refer to this one.

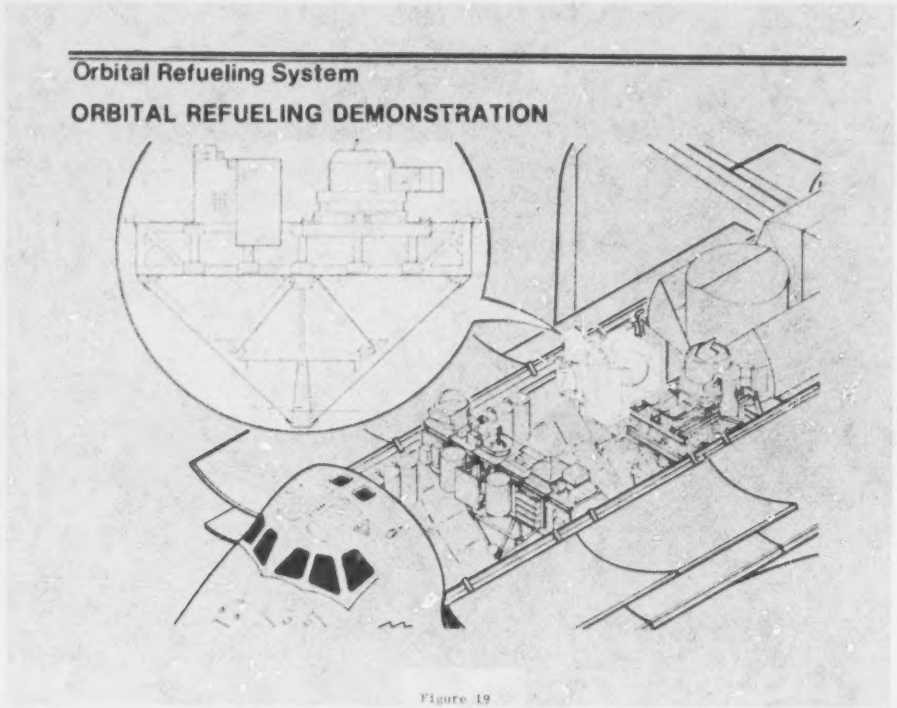


Figure 19

On the 17th flight, we will have an EVA demonstration (figure 19) of transfer of fuel to the two different types of the basic storage tanks that are used in satellites now. And this is quite critical to us because the Landsat as you know is in a degrading mode right now, and this is an important element in getting ready not only to repair the Landsat but then to refuel it. So this program, we think will fit in quite well with what is happening with the Landsat.

ADVANCED TRANSPORTATION OBJECTIVES

- **EARTH-LEO**
  - REDUCE COSTS
  - MORE VOLUME,WEIGHT
  - FLEXIBLE MANIFESTING
- **LEO-GEO**
  - REDUCED COSTS
  - LONGER STAYS
  - RETURN PAYLOADS
  - FLEXIBLE SATELLITE MANIFESTING
  - PLANE CHANGES
  - MANNED MISSIONS
  - LOW "G"
- **LEO-ESCAPE**
  - CONTINUOUS THRUST

Figure 20

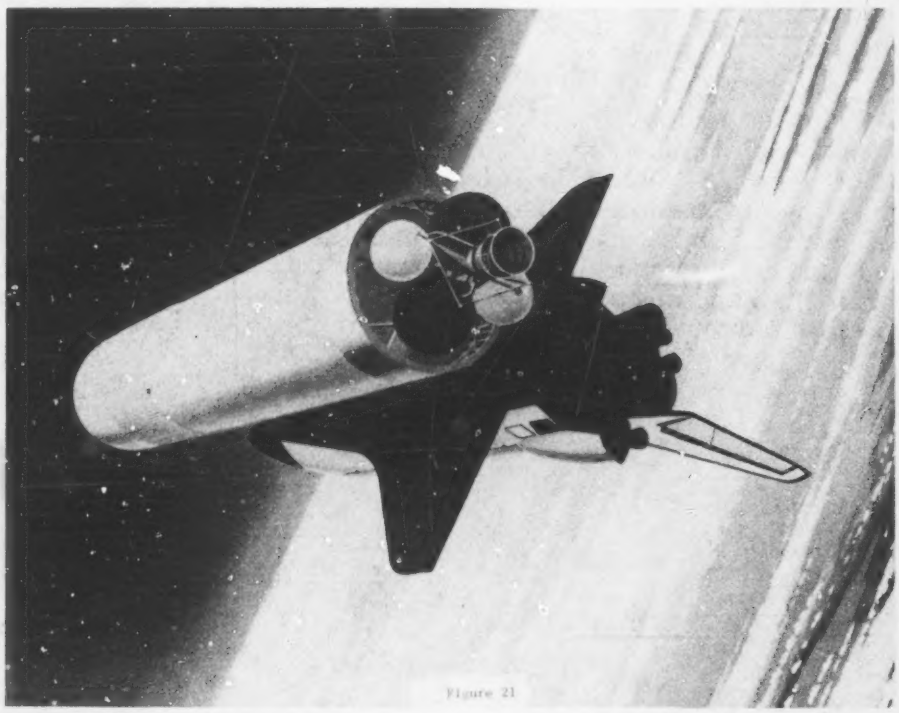


Figure 21

Our advanced transportation objectives are to improve our ability to operate between Earth and lower orbit. We have a series of shuttle derived launch vehicles (figures 20 and 21) which may be

manned or unmanned which could support that and those studies are presently being looked at and they could offer, in fact, a backup or an assured launch for the Department of Defense and for some of our commercial customers. I still look for that to be a problem area. Something that may be useful over and above some of the commercial endeavors. This is the area that has not filled and that's the low earth orbit—the geosynchronous orbit. We are interested in the ability to find ways to get there so that you can have, in fact, sufficient energy, to make plane changes and meet some of those satellites.

To have manned missions and to assemble in lower orbit and then move very slowly at low accelerations on some of the large antennas structures that we think might come in the future.

This is a requirement as we look at that, and then, of course, the planetary program we will still be interested in the escape.

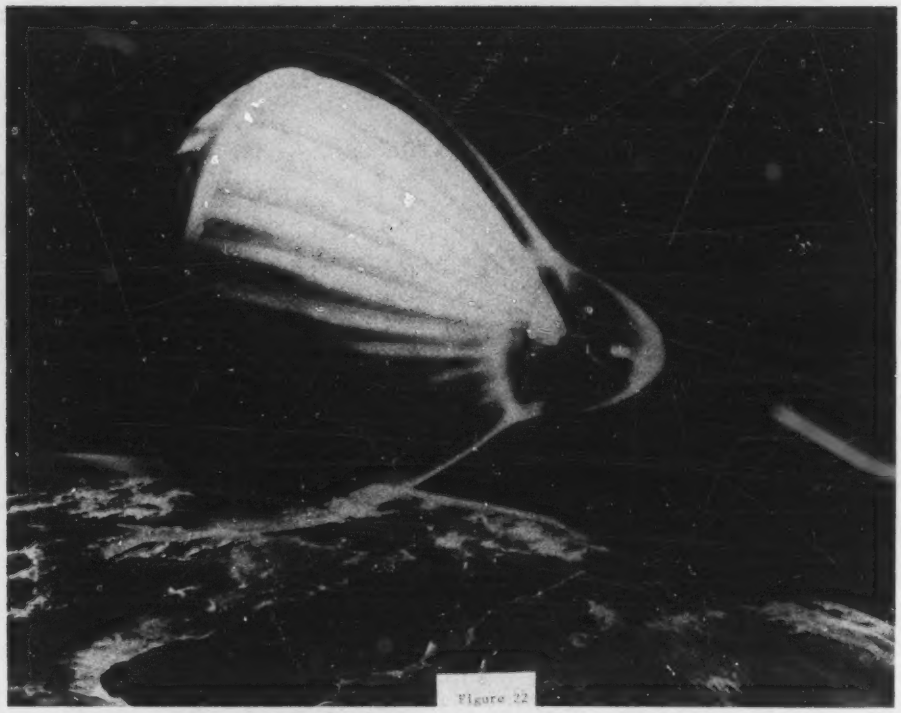


Figure 22

Here is one version (figure 2) of that, this would go inside the aft cargo carrier that I mentioned and this is a shuttle optimized concept of an orbiter transfer vehicle and this has been in study for some time. It could be, it could make use of such things as ways to reduce the fuel associated with getting up to orbit, and then getting back, and getting slowed down with the geosynchronous orbit, and getting slowed down by this aerobraking which is what we call a baluth, it is a large balloon that expands and provides a way to protect the spacecraft as you come in. And we are looking at now the potential of doing a research demonstration with the shuttle for using that kind of technology.

PLATFORMS/CARRIERS OBJECTIVES

- **FREE/TETHERED**
  - AGGREGATION OF PAYLOADS
  - ACCESS BY SHUTTLE/SPACE STATION
  - ECONOMICAL SUPPORT
  - PAYLOAD EXCHANGE
  - PLATFORM SERVICING/REFUELING
- **AT ORBITER**
  - FLEXIBLE MANIFESTING
  - QUICK REACTION
  - INDEPENDENT CREW INTERFACE

Figure 23

Figure 24

There are a series of platforms and carriers (figures 23 and 24) which we think will be important and we are also, with your approval this last year, we are proceeding with a tethered satellite,

here is a picture of what the Italian version of the tethered satellite might look like. That satellite is in construction at this point in time.

The platforms are particularly attractive and there are at least three different versions of commercial space platforms that are now in discussion, as well as two versions in Europe which will be coming from the ESA community.

CREW AND LIFE SUPPORT OBJECTIVES

- ZERO PREBREATHE
- LONG DURATION
- LIGHT WEIGHT
- LOW RESUPPLY/LOGISTICS
- EARTH-NORM HABITABILITY
- FOR BOTH FACILITIES AND PORTABLE

Figure 25

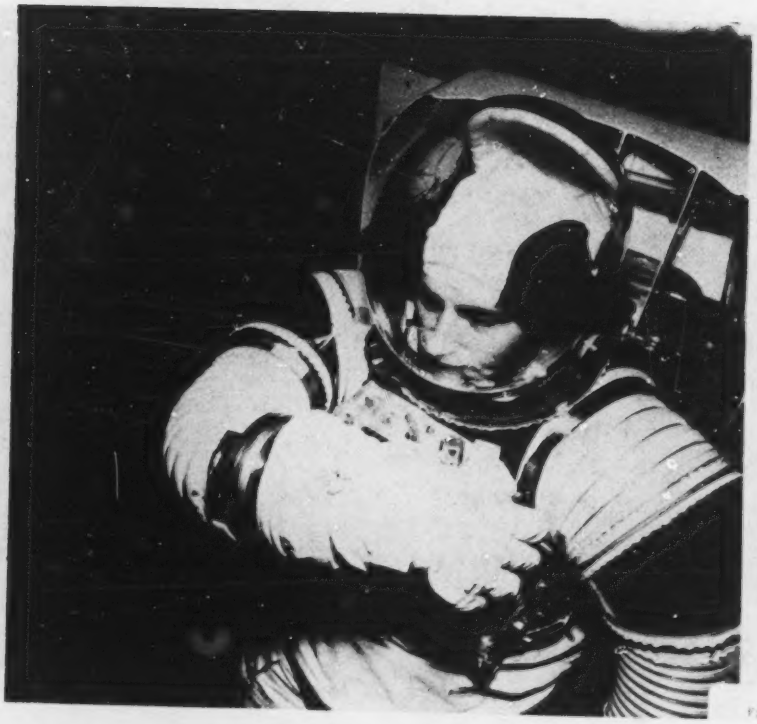


Figure 26

In order to support EVA (figures 25 and 26) with the shuttle in the future as well as the space station, we think that there are important improvements that must be made in our ability to go outside of the vehicle. We are looking at crew and life support systems that will allow us to avoid this long period of prebreathing that allows you to get out quickly for emergency conditions. I briefly tried this 8-PSI suit when I was down at Johnson. This is a prototype of one that could be constructed in the future, but it is a test system with different arms, legs, and different gloves.

We are looking for this one which would be particularly important for space station applications because the suits will have to stay up on the space station for a long period of time, and we can't support it the way we are presently supporting the shuttle suits and, of course, really, make it very habitable and affordable. So, there are initiatives in that area within the Agency.

Synopsis of ADVANCED PROGRAM PLAN

- SYNTHESIZED TO MEET AGENCY GOALS
- ENABLES FUTURE MISSIONS
- SUPPORTS PERMANENT PRESENCE THROUGH
  - INFRASTRUCTURE ELEMENTS

	START	IOC
• Teleoperated Maneuvering System	FY 85	FY 88
• Aft Cargo Carrier	86	89
• Orbital Transfer Vehicle	87	92
• Platforms, Suit	88	92
• Shuttle Derived Launch Vehicle(?)	89	94
• OTV Crew Capsule	90	95

  - SPACE OPERATIONS AND SERVICES CAPABILITIES
- FEATURES EXTENSIVE FLIGHT R&D/EXPERIMENTS USING SHUTTLE
- IS COOPERATIVE WITH OTHER OFFICES, SPACE STATION
- IDENTIFIES NEED FOR ENHANCED ADVANCED DEVELOPMENT AND SYSTEM DEFINITION

Figure 27

In essence, our advanced programs (figure 27) are aimed at filling in the infrastructure associated with the programs. We tried to insure that we meet the entire Agency goals for these future missions and here are potential start dates. Obviously they are subject to both the overall priorities as judged by the administration and by your committees in Congress, but there are times in which they are laid out in the 5-year plan as potential times. The first of these that we are now examining is the teleoperating maneuvering system in conjunction with the 1985 budget. Now, whether or not we're able to initiate that, of course, depends on the budget process.

We do feel that it's imperative that the shuttle be used as an R&D vehicle, not only for Government objectives but for the commercial objectives that we talked about. I would like to point out one example because I've been asked by the press—the flight crew was asked by the press—and I think it's an important one. We are prepared to go a very long long way in helping some of these endeavors. We will fly on the 12th mission Mr. Charlie Walker from McDonnell Douglas as part of our joint endeavor agreement. He is one of the key designers of the electrophoresis unit that McDonnell Douglas has made.

Our objective is not only to give him an opportunity to fly in space and operate his machine in space, but more importantly to take that lesson back so that as he designs his manufacturing unit for the future, and for future applications, to really have an intimate knowledge of what that all means. So that is an important step, we feel, and that is part of our expanded flight program in bringing additional people into the program. So, we all feel that the joint endeavor is a very flexible instrument to encourage people not only to invest but to take on really exciting and difficult

challenges. We will go as far as flying people in order to help them in that effort.

With that, sir, I'll finish the briefing.

Mr. VOLKMER. Thank you very much, General Abrahamson. I have several questions.

When do you plan to do—you said it there and I forgot it—the refueling?

General ABRAHAMSON. That will be on our 17th mission, sir, and that will be next fall.

Mr. VOLKMER. Late 1984?

General ABRAHAMSON. Yes, sir. Depending on how our schedule all holds.

Mr. VOLKMER. I did ask you about the August 20 on eight, and what happens there will have some impact—at least press reports I've read—on what happens on nine and whether nine is put off to the alternative date.

General ABRAHAMSON. Yes, sir.

Mr. VOLKMER. We don't have ten anyway; is that correct?

General ABRAHAMSON. That's correct. Actually we can delay nine without any impact on the schedule at all. That's just a nice option that has happened because the DOD flight has fallen out. But it allows us a great deal of flexibility. Nonetheless, we would still like to get both flights off as early as we can, and that's ESA's desire as well. So, as we make this schedule decision it will be a joint decision between NASA and ESA on nine, and the eight decision is to try to make—add confidence to the nine flight.

Mr. VOLKMER. All right.

As I understand the last viewgraph there, I guess we're going to go ahead with the OTV before we have a space station.

General ABRAHAMSON. That's a final judgment, of course, that Mr. Beggs and the Administration and the Congress will have to make. But as we are doing our studies——

Mr. VOLKMER. You do the planning?

General ABRAHAMSON. Yes, sir.

As we are doing our studies we are trying to bring the initial studies to a state of maturity so that if that were approved by the administration and by the Congress we would be prepared to do that. Now, if you look at what Mr. Beggs indicated, that there is a definition phase on the space station as well, you will see that that falls in about the same time for both starts in terms of serious activity on that. So we think it's coordinated.

Mr. VOLKMER. An OTV, though, wouldn't be used for any longer than your shuttle is up there?

General ABRAHAMSON. There are two concepts. One is a ground-based orbital transfer vehicle, and that's one you would take up, for example, in that aft cargo carrier. We think that ultimately the important one is one that can stay in space. The Centaur is an example of a ground-based one now which could perhaps grow to a space based OTV. But we think that in the end you want one that can just be used repeatedly in space which means it should be maintainable in space as well.

Mr. VOLKMER. I have no further questions.

Does the gentleman from Texas have any questions?

Mr. ANDREWS. I have no questions, Mr. Chairman.

Mr. VOLKMER. Does the Chairman of the full committee have any questions?

Mr. FUQUA. I just have one.

I want to thank you for being here, Jim, and for doing a very fine job.

The chart that you had on the Orbiter that you were talking about the Atlantis being scheduled for 1984—December 1984—delivery.

General ABRAHAMSON. Yes, sir.

Mr. FUQUA. What would be the optimum delivery date on the fifth orbiter should that decision be made?

General ABRAHAMSON. Optimum delivery date. I think in any event we are in a situation where we have an extended timeframe. We will not deliver them as we have been here every 18 months or so. I think we are now at a point where a sensible manufacturing program is one that dictates about a 3-year delivery at the very least. A 3-year span time, given that we have started out with the structural spares program which allows that, may well provide a very effective manufacturing plan based on where we are at this point.

Mr. FUQUA. The fact that they've been delivered about every 18 months, then to slow that—that would then in effect slow that last orbiter down?

General ABRAHAMSON. Yes, sir.

Mr. FUQUA. Would that increase the costs?

General ABRAHAMSON. Yes, sir. It certainly would.

Mr. FUQUA. Then the optimum time would be about 18 months with the flow as it is currently going, would it not?

General ABRAHAMSON. If we had not already made adjustments in terms of our work force and the manufacturing concept. We are now doing that. We are trying to trim down to a one station manufacturing facility so we can have an extended operation but have that extended operation be as efficient as possible.

Mr. FUQUA. Thank you.

General ABRAHAMSON. Quicker is always cheaper, sir.

Mr. VOLKMER. The gentleman from Pennsylvania?

Mr. WALKER. Thank you.

Of the new reservations that you have received for shuttles, since January, how many are foreign and how many are commercial?

General ABRAHAMSON. I will have to get that information for the records.

Mr. WALKER. I would appreciate that.

[The material referred to follows:]

Space Shuttle reservations received since January for foreign and commerical customers are as follows:

Foreign	4
Commerical	13
Total	17

Have you done any evaluations of alternatives to the fifth orbiter such as more advanced concepts for use of the orbiters now in place?

General ABRAHAMSON. Yes, sir. An example of one kind of a way of approaching that would be for the Centaur to have a dispenser

which carries up several of the communication satellites and all going up on one transfer vehicle and then they can all just roll out of that and go out and drift to their proper position. That is an alternative of the kind that you mentioned, so we have looked at several of those.

One of the problems that we run into is the problem of how many that you can effectively manifest on one particular flight, and you have to remember that each of these companies have their desires in terms of timing. They have a customer base that they also have to respond to. So you must look at what is an efficient and effective way of doing it technically, but you also must look at what the operational limits are, and sometimes they are not coincident.

Mr. WALKER. Has there been any thought given at any point to using the shuttle for anything other than orbital flight; for putting propulsion systems on it in space and using it for more deep space activities?

General ABRAHAMSON. There were some early looks at that. Because the shuttle is so heavy, it's just not a very efficient vehicle to go beyond just a very limited range of operation in low earth orbit. Therefore, we really feel that the only way to effectively do that is with a separate, more optimized, vehicle.

Mr. VOLKMER. Will the gentleman yield?

Mr. WALKER. I'd be glad to.

Mr. VOLKMER. In regard to that, what about the possibility of extending orbit period?

General ABRAHAMSON. There has been considerable study at that particular—for that particular objective. I did take action early to put a fifth cryogenic set on the fifth orbiter and, of course, that's what allows us to operate our Spacelab missions for some 2 extra days and still have a reserve beyond that. So that was a rather simple, low-cost, change that we could make. There are other power generation systems that could be developed for that kind of extended operation. That has two effects: One, it's an efficient way of doing things. By the way, it also impacts the ongoing fleet in operations so there are disadvantages as well. There are technical ideas that are well developed for that. We just have not seen a clear requirement at this point in time.

Mr. VOLKMER. The gentleman from California, do you have any questions?

The gentleman from Florida have any questions?

Mr. BROWN. I have some questions but these gentlemen were here before I was.

Mr. VOLKMER. The gentleman from Texas has already been recognized.

Mr. BROWN. General, I appreciate your presentation. It was very good.

I have a question with regard to the matter of the fifth orbiter and how it would be affected if we are able to crystalize plans for space station and OTV. Would this affect the requirements in timing for fifth orbiter? Are the plans coordinated in any way?

General ABRAHAMSON. I think it's affected in two ways and both of them are push it in opposite directions. In terms of the building of the space station and the resupply of the space station, that

would tend to put more requirements on the shuttle manifest. Therefore, you would require more flights. However, operating in the opposite direction, some of the work that we anticipate in the future would be reduced because we think some of the manufacturing operations would take place over a much longer period of time on the space platform. Therefore, you could consolidate things and have fewer flights. In addition to that, some of the repair activity, associated with the space station, that the space station can do on other satellites would decrease the number of satellites that would have to be built, and take up and launched, because they could be returned from either geosynchronous orbit, with an orbital transfer vehicle, or from low earth orbit brought over with a teleoperated maneuvering system to the space station and hopefully repaired and refuel and then put back. So there are conflicting demands here. That really depends—I can't give you a net answer, sir, that it goes up or down, but I can point out that there are both trends that are there.

Mr. BROWN. Well, obviously, there are conflicting budgetary demands.

General ABRAHAMSON. Yes, sir.

Mr. BROWN. But my main concern is that the full picture is being looked at so that we can see these demands and resolve them from a policy standpoint.

General ABRAHAMSON. Those are some of the studies that Mr. Beggs indicated. They are the technical tradeoffs that now have to be made as we proceed.

Mr. BROWN. Let me explore a very delicate question with you. As you know we have a very extensive military space program. This program has an overlapped period.

For example, an OTV, I am sure, would have definite military applications as well as civil application in connection with repair, launching and all the other things that you have visioned.

Is there in your opinion, an adequate coordination with the military in connection with the planning for this kind of project.

General ABRAHAMSON. Sir, I believe there is.

There are several committees of different kinds that have operated; and, of course, in our space station studies, starting with the requirement studies as well as some of the in-house studies, the Agency has brought the Department of Defense representatives in for those studies.

Perhaps the best example of how that coordination can bear fruit is the Centaur itself, which is in an orbiter transfer vehicle and the program plan is one of shared funding and a program that goes ahead with a vehicle that meets NASA's needs and then also, can meet the military needs. And I think that from a national viewpoint that is ideal when the requirements are that coincident that we can achieve that. I believe that we are having a full communications with the Department of Defense on all of these programs.

In many cases, they do not have a clear requirement at this point in time.

Mr. BROWN. Well, I am particularly sensitive right now because of the debate that we have had on the ASAT, and it seems to me that the military is spending a lot of money on a ASAT, and I don't want to get into a policy argument on this right now.

But essentially a maneuverable OTV could fulfill a lot of the requirements that an ASAT fulfills. We would be better off to avoid the hassle and concentrate on a maneuverable OTV rather than to spend all that money on ASAT. That is one man's opinion, of course, but the problem that I have is any feeling that this kind of policy issue is being debated at the policy level in the executive branch and I have no feeling as to whether that is being done or as to where it would be done.

General ABRAHAMSON. Let me comment on the procedure, sir.

We have, as I indicated, several working groups. Some of those working groups are working groups for a specific subject that are only between NASA and the Department of Defense. An example of a working group of that kind is where we are examining the potential of using one of the 747's that has now been authorized and appropriated for improved air-lift capability within the Department of Defense as a backup for improved orbiter carrier for the system. So that is going on and that is an example of a separate working group.

For the space station here, we have an example of working groups that are chartered under the senior interdepartmental group on space and that coordination then takes place; first at the working group level and then, of course, in more formal policy debates and discussions in the context of the SIG meeting itself prior to the time that that paper goes forward to the President.

So I feel there is, in fact, adequate coordination.

Mr. BROWN. I have one additional question.

When you talk about commercialization of the expandable launch vehicles, do you feel that this could be counterproductive in achieving cost-effectiveness by the space shuttle program?

General ABRAHAMSON. Let's assume the ELV commercialization is successful. I feel that first of all the ones that will be successful as long-term businesses, will be the ones that in the end complement the space shuttle. And that is, that they will provide a service that the space shuttle can't economically or routinely and operationally deliver. And that may be to provide satellite service or payload delivery service to orbits that we would not often go to or with payload sizes or something that we can't easily integrate into our overall manifesting.

So in that sense, I really believe that the companies that are looking in that direction will have the most viable long-term business. In terms of the others, there was one case of clear competition recently, of course, with the proposal on the INTELSAT 6 series of spacecraft.

So, in some isolated cases, I think there will be, in fact, some direct competition.

I hope that in the end the business judgments that the people will make will be such that the U.S. will present a very formidable array of launch vehicle capability through what the Government is providing on the space shuttle and what, through the commercial people, will provide in a supplementary way.

So we think, that is, well there may be some isolated competitions, but in the end I think it will resolve itself when what makes good business sense in the long term.

Mr. VOLKMER. About what year, do you think, if you can define a year, are we looking at a possibility of a manned OTV?

General ABRAHAMSON. We think that is late in the 1990's. Perhaps in the 1990 timeframe. I personally would like to see that much earlier because I think that man can contribute a great deal as to a synchronized orbit, but we do see that it is possible by the 1995 timeframe.

Mr. VOLKMER. Do you have, along with your presentation to us, this chart, you know of the times?

General ABRAHAMSON. Yes, sir.

I pulled that because it was out of date. It didn't indicate that the seventh flight had flown successfully.

Mr. VOLKMER. Could we, it is hard for me to read it. It is very easy for me to understand it easy that way where we are looking as far as payloads are concerned. Could you furnish us with an up-to-date——

General ABRAHAMSON. A key for that.

Mr. VOLKMER. Right.

I would appreciate that.

Are there any further questions.

Well, thank you very much, General Abrahamson. I appreciate your being here today, and your testimony has been very helpful and we will not stand adjourned until Thursday at 1 o'clock.

[Questions and answers submitted for the record follow:]

Written responses to questions submitted during the hearing on July 26, 1983, before the Subcommittee on Space Science and Applications concerning the Office of Space Flight's five-year plan.

QUESTION M-1:

Now that NASA has determined to construct the SRB refurbishment facility at KSC, what is the schedule for designing and constructing this facility? Who will manage this effort?

ANSWER M-1:

The Request for Proposal (RFP) requires the selected contractor to provide a design for an SRB refurbishment facility. The contractor will start construction of this facility in mid-1984 with an anticipated completion in mid-1985. While the plan is to have the contractor fund this facility and manage its construction, the government will reserve the right to fund this facility on its own if its determined to be most advantageous.

QUESTION M-2:

When will NASA submit an SRB manufacturing plan as requested in the Committee's authorization report which accompanied H.R. 2065?

ANSWER M-2:

The SRB manufacturing plan requested in the Committee's authorization is presently targeted to be provided by November 1, 1983.

QUESTION M-3:

What progress is being made on reducing turnaround time on SRB reusable hardware and what is included in the five-year plan for this purpose?

ANSWER M-3:

Significant progress is being made on reducing turnaround time. A productivity improvement program is underway with planned improvements initiated on the STS 8 flight boosters. These include changes such as deletion of measurement requirements, revised fastener closeouts, reduction in TPS sampling, and relaxation of Thrust Vector Control (TVC) tube bend radius. The five-year plan includes improvements such as redesign of the systems tunnel (which protects electrical cabling and range safety linear shaped charge) to enhance assembly, alternate TPS material to decrease installation time, redesign of closeout requirements for field joints, and simplification of attach ring covers.

QUESTION M-4:

What additional effort is included in NASA's plans to minimize impact damage to the SRB's? Specifically, what progress has been made on improvements to the SRB thrust vector control system?

ANSWER M-4:

The most significant efforts are related to minimizing damage to the aft skirts and TVC subsystem. The aft skirts have been strengthen by adding gussets and in addition foam has been applied between the aft skirt rings to distribute the water impact loads. These changes were incorporated on STS-7 which proved to be effective in minimizing impact damage. In addition to these modifications, efforts are underway to assess the contribution of using larger parachutes in order to decrease the water impact velocity.

There is currently an aggressive program to improve the survivability of the Thrust Vector Control system both in terms of elimination of damage and system simplification. Actions have already been implemented in providing protective barriers to the TVC system and application of foam to prevent damage at water impact. There are also efforts underway to modify selected TVC system components to eliminate water intrusion. These actions will reduce refurbishment requirements and provide a reduction in turnaround.

[Whereupon, at 10:30 a.m., the subcommittee adjourned until Thursday, July 28, 1983 at 1 p.m.]

APPENDIX

National Aeronautics and
Space Administration

Washington, D.C.
20546

C:LVN:mdd

SEP 20 1983

Honorable Don Fuqua
Chairman
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

During the July 26, 1983, hearing at which Mr. Beggs testified on NASA's five year planning, Gen. Abrahamson inadvertently misquoted the company names for those companies responding to our request for information on the expendable launch vehicles.

Therefore, NASA would like the record amended as shown in enclosure 1, to correct the statement.

Sincerely,

for John F. Murphy
Assistant Administrator
for Legislative Affairs

Enclosure

cc:
Mr. Darrell Branscome

25th Anniversary
1958-1983

The request for expressions of interest in the commercialization of Centaur was answered by four companies: General Dynamics, FEDEX Space Transportation Company, CSC, and UTC's Chemical Systems Division. The Delta request was answered by five companies: Space Services Incorporated, Transpace Carriers, FEDEX Space Transportation Company, CSC and UTC's Chemical Systems Division. RCA Service Company expressed interest as a potential subcontractor only.

NASA'S FIVE-YEAR PLAN

THURSDAY, JULY 28, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 1:10 p.m., in room 2325, Rayburn House Office Building, Hon. Harold Volkmer (chairman of the Subcommittee on Space Science and Applications) presiding.

Mr. VOLKMER. The Subcommittee on Space Science and Applications will come to order.

With today's hearing on Tracking and Data and Space Science and Applications and Space Technology, we will conclude our hearings on NASA's 5-year plan.

We are interested in looking at NASA's plans over several years because such an investigation can reveal trends that are not always obvious in our traditional year-by-year authorization process.

For example, in the Space Science and Applications area, we want to make sure that NASA maintains a healthy applications program.

Another concern is the planetary program. We want to see it recover from the low point of a few years ago and we want to compare NASA's plans to the recommendation of the Solar System Exploration Committee.

The office of tracking and data has a unique role within NASA and that is to provide operational support to both manned and unmanned spacecraft and disseminate and analyze the data where appropriate.

This role is extremely important and requires the most sophisticated hardware and brainpower we can devote to this activity due to the rapidly advancing technology and pace of the programs.

We look forward to reviewing the tracking and data plans and participating in this exciting mission that continues to grow each year.

Let me congratulate you for your splendid recovery of the first TDRSS satellite and hopefully in the not-too-distant future we can have this system operational.

Now, our final witness will describe the space research and technology program and this is where many new NASA technologies are developed.

We will now proceed with the hearing.

First, do you have a statement?

Mr. LUJAN. I do.

Mr. VOLKMER. I will now recognize, before we proceed with our first witness, the gentleman from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman, and I want to commend you on holding these hearings. It's important to pull back and look every once in a while at the long-range direction.

These hearings provide us with an excellent framework for the hearing on the review of the Space Act, which is scheduled after the recess.

There is one area that I am particularly interested in discussing with our witnesses today and that is the ability of NASA not only to develop new technologies (of course, NASA is great at that); but to assure that these technologies and the knowledge is put to maximum use by both the private sector and other Government agencies.

To my mind, that's a large part of the purpose of NASA. I am also interested in how NASA works with the universities. Do they, the universities, have valuable expertise; are we taking advantage of that expertise and are the universities producing the kind of young scientists and engineers that NASA will be hiring over the next few years? There are many exciting programs under the management of our witnesses today. Some of the programs have had their troubles or controversies, such as the space telescope, TDRSS and so on, but we can hear today how all the problems have been resolved and continue to see good results.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you.

We will now proceed with our first witness, Dr. Burton Edelson, Associate Administrator, Office of Space Science and Applications.

As I understand it, you will proceed with viewgraphs; you do not have a prepared statement. You will use the viewgraphs, is that correct?

Dr. EDELSON. That's correct, Mr. Chairman.

Mr. VOLKMER. All right. You may proceed.

STATEMENT OF DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE SCIENCE AND APPLICATIONS

Dr. EDELSON. Well, I am very pleased to be here this afternoon, Mr. Chairman and members of the Subcommittee on Space Science and Applications.

We are here—a group of us from NASA—to talk about NASA's advance planning.

Mr. VOLKMER. Dr. Edelson, would you pull that mike just a little closer and let's see if it's on?

Dr. EDELSON. I know that Mr. Beggs was here on Tuesday and spoke to you about our overall planning procedures and mentioned the fact that we look ahead as much as 20 years which means into the next century, and consider the missions that we might like to do, that we might be technologically capable of doing and that would provide benefits of various kinds to our scientific program, to

our national security and to the welfare and commerce of this Nation.

Although we do, indeed, look ahead as long as—as far as two decades and have some grand ideas for the far distant future, we do a rather intensive program of planning over the next immediate 5-year period and it is the set of 5-year plans which we are presenting to you now. I know that Mr. Beggs went over the overall NASA goals with you and recognized in his overall presentation of the NASA program the importance of scientific—of the science and applications missions, which I will speak in some detail about today. Mr. Beggs also referred to the agency's hopes and plans for a space station program and one of the things I will mention is the role of science and applications in the NASA space station program.

I'm here to present the space science and applications' 5-year plan. I will cover our more specific objectives, our plans, I'll describe some of our programs. I think that you will discern, or at least I shall assert, that our program is very healthy today. I hope that you will discern an improvement over the last few years in which we have tried to reorganize some programs, start other new programs and we've made particular progress with the help of your subcommittee, Mr. Chairman, in the planetary science area and solar system exploration where we have now an ongoing vigorous program. We have organized an Earth science and applications program which is rather a new orientation for NASA's programs, aimed at comprehensive viewing of the planet on which we live as a system. And, we've made particular progress in communications and have a very forward-looking high-technology program in satellite communications.

I'd like to start now and show you some of the—some of our plans and programs, starting with the NASA goals on the left, figure 1.

27-459 O—83——5

NASA GOALS

- PROVIDE FOR OUR PEOPLE A CREATIVE ENVIRONMENT AND THE BEST OF FACILITIES, SUPPORT SERVICES, AND MANAGEMENT SUPPORT SO THEY CAN PERFORM WITH EXCELLENCE NASA'S RESEARCH, DEVELOPMENT, MISSION, AND OPERATIONAL RESPONSIBILITIES.
- MAKE THE SPACE TRANSPORTATION SYSTEM FULLY OPERATIONAL AND COST EFFECTIVE IN PROVIDING ROUTINE ACCESS TO SPACE.
- CONTINUE TO EXPLORE THE REQUIREMENTS, OPERATIONAL CONCEPTS AND TECHNOLOGY ASSOCIATED WITH PERMANENT SPACE ACTIVITIES.
- CONDUCT AN EFFECTIVE AND PRODUCTIVE AERONAUTICS RESEARCH AND TECHNOLOGY PROGRAM WHICH CONTRIBUTES MATERIALLY TO THE ENDURING PREEMINENCE OF U.S. CIVIL AND MILITARY AVIATION.
- CONDUCT AN EFFECTIVE AND PRODUCTIVE SPACE AND EARTH SCIENCES PROGRAM WHICH EXPANDS HUMAN KNOWLEDGE OF THE EARTH, ITS ENVIRONMENT, THE SOLAR SYSTEM, AND THE UNIVERSE.
- CONDUCT EFFECTIVE AND PRODUCTIVE SPACE APPLICATIONS AND TECHNOLOGY PROGRAMS WHICH CONTRIBUTE MATERIALLY TOWARD U.S. LEADERSHIP AND SECURITY.
- EXPAND OPPORTUNITIES FOR U.S. PRIVATE SECTOR INVESTMENT AND INVOLVEMENT IN CIVIL SPACE AND SPACE-RELATED ACTIVITIES.
- ESTABLISH NASA AS A LEADER IN THE DEVELOPMENT AND APPLICATION OF ADVANCED TECHNOLOGY AND MANAGEMENT PRACTICES WHICH CONTRIBUTE TO SIGNIFICANT INCREASES IN BOTH AGENCY AND NATIONAL PRODUCTIVITY.

E-1

The Science and Applications program that we have stems from those two goals—two of NASA's goals, which Mr. Beggs covered on Tuesday and which serve as our guidance for the specific objectives which are shown on the righthand panel, figure 2. You'll notice that the objectives which we recognize in the Office of Space Science and Applications are of two types—our planning objectives and our management objectives.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
OBJECTIVES

PROGRAM PLANNING:

- DEVELOP LONG TERM STRATEGIES FOR EACH PROGRAM AREA
- DEVELOP FIVE YEAR PLAN AND IMPLEMENTATION SCHEDULE FOR EACH AREA
- PREPARE DETAILED FY 1985 BUDGET PROPOSALS, WITH RATIONALE FOR NEW STARTS AND INITIATIVES
- DEVELOP FUTURE EXPLORER INITIATIVES AND INITIATE PLANETARY OBSERVER CLASS
- DEVELOP GLOBAL HABITABILITY CONCEPT
- DEVELOP PLAN FOR USE OF FREE FLYERS, SHUTTLE, LARGE PLATFORMS, AND SPACE STATION

MANAGEMENT:

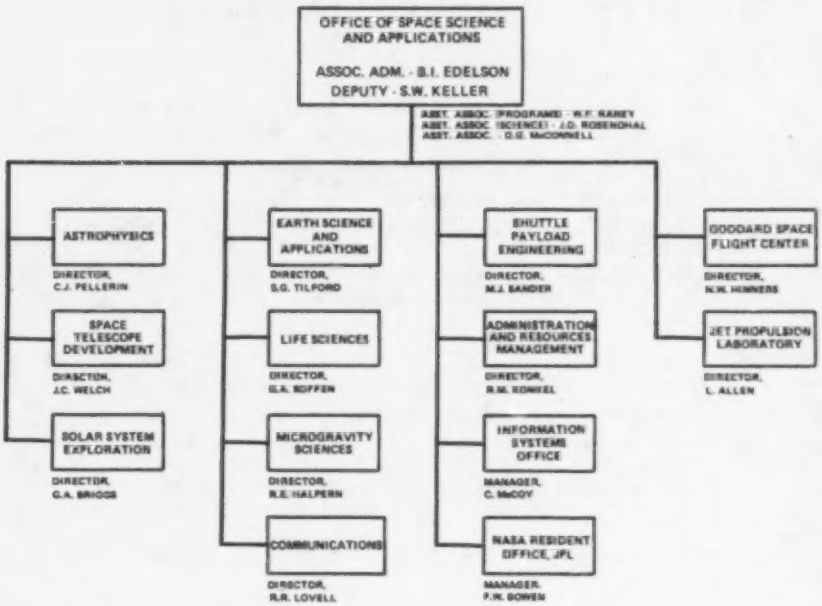
- PROVIDE EFFECTIVE CONTROL OF MAJOR FLIGHT PROJECTS
- COMPLETE REALIGNMENT OF OSSA DIVISIONS AND OFFICES
- PROVIDE EFFECTIVE GUIDANCE AND OVERSIGHT FOR REPORTING CENTERS
- MAINTAIN HIGH LEVEL OF TECHNICAL COMPETENCE IN OSSA STAFF; PURSUE EQUAL OPPORTUNITY GOALS; FOLLOW-UP ON FRESH-OUT INITIATIVE
- PURSUE PRODUCTIVITY ENHANCEMENT THROUGH AUTOMATION AND OTHER ADVANCED TECHNIQUES

E-2

I won't read through there, but I will emphasize that these objectives—which were not, incidentally, made up just for this particular presentation—start out with the concept that we will develop a strategy and a 5-year plan for each of our program areas. We have spent, over this last year, a great deal of time and effort trying to assess the potential for science and applications of different programs; of rating these programs as far as technological capability is concerned; and prioritizing them in our overall plan which is not by any means an easy task, so that the results which I will present to you today are the result of a good deal of analysis, soul-searching and organization.

You may notice in there that the words global habitability is one of our plans, and that is a subject which we are addressing very aggressively. It is not a budget line item, so you'll not see it in the rack-up of projects which have budget attached to them. Rather, it's an umbrella program which is aimed at studying, analyzing, measuring the Earth as a system and developing a capability to predict the effects of—upon our environment, and estimating the long-term future of biological productivity of this planet and of habitability of all life forms on this planet into the future. A very exciting and interesting program. I'll have a few more words to say on that later on.

Of course, planning—about which I'm speaking mostly today—is essential, but it's all—but the best laid plans—not to quote—are not very useful if you don't have a strong management. And so we also have a set of management objectives, which we try to follow, which will carry forward the program efficiently and effectively to meet schedules, cost goals and technical objectives of each of our missions.



E-3

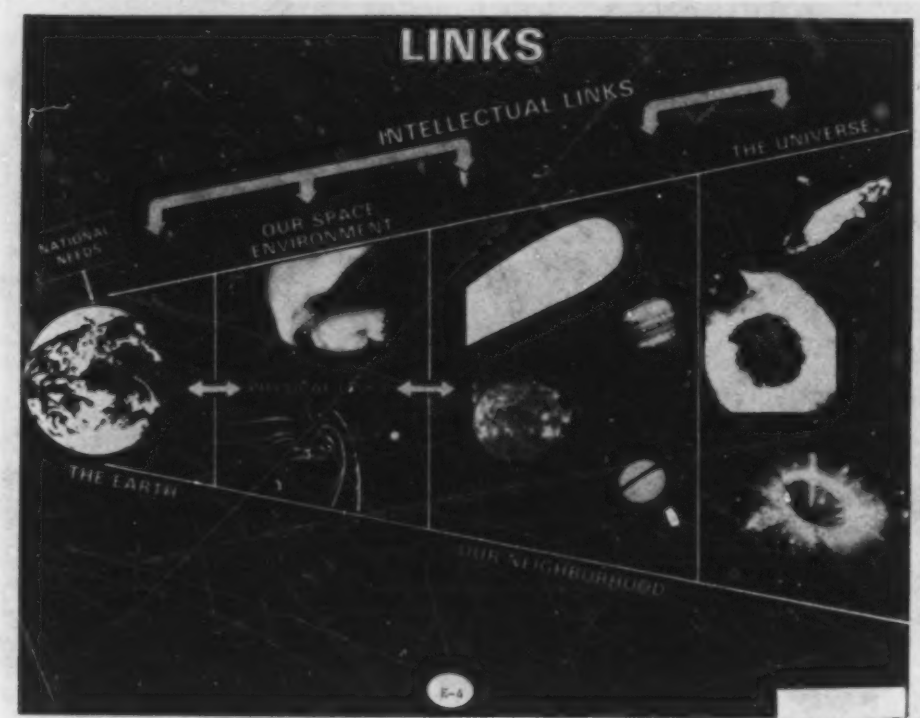
I thought I would show you what our organization chart (figure 3) looks like. On the left, you'll see that we have organized them into a somewhat different fashion. I have 11 boxes in headquarters that report to me. When I strung them out horizontally, it was obvious to me that that would be interpreted as not a very good organizational arrangement, because management principles uphold that you shouldn't have 11 boxes reporting into one; that's too large a scope of control. So I fixed that by drawing the chart a little bit differently. It is a problem to some extent because it's necessary in a science and applications program in high technology to have very direct access—to put a lot of control and capability in the hands of the director of each program division, without layering it with a lot of administrative management.

It's a problem which NASA wrestles with all the time and in my office it's particularly acute—a problem of merging very high technology science and applications programs with a good management structure. You'll also note on there that we are responsible institutionally for the two science and applications centers—the Goddard Space Flight Center here and the Jet Propulsion Laboratory in Pasadena, Calif.

Those of you who have been familiar with the organization over the years know that, just a year and a half ago, we merged the two sciences—the two Offices of Science and Applications into a single office and changed the reporting procedure for the institution so that the center directors report to the associate administrators.

I am pleased to report that at least in—from my own observation, that organization is working very well. There are some economies in merging two organizations together; but, it also provides a

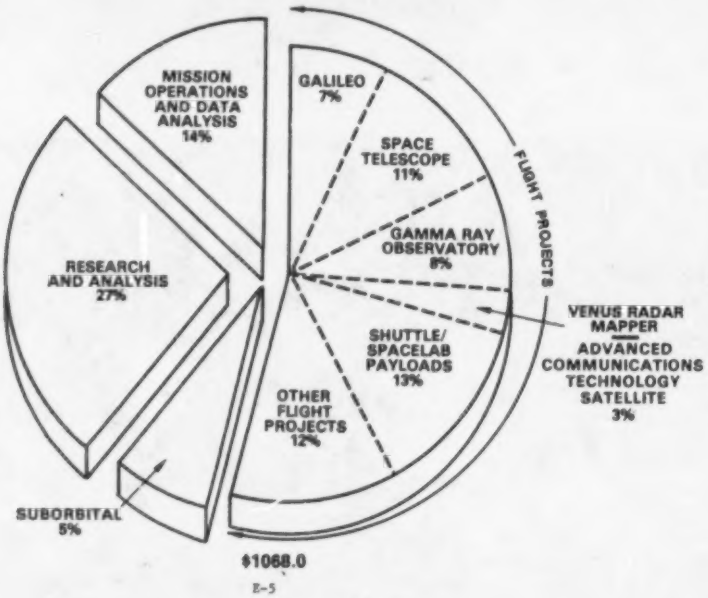
very healthy support and recognizes the very great amount of science that always has been and continues to be in the applications missions and recognizes the engineering and applications technology that's inherent in all of these science programs. And, it provides a very good balance within the Agency to have one program-oriented office which is able to address overall programs like, as I say, Global Habitability; like the space station program and so on.



The viewgraph on the right (figure 4) is intended to bring home the thought that there is a lot of linkage between our programs. We reach out some 18 billion light years or so to the very edge of the universe as we are able to understand it.

We are studying distant galaxies and the most energetic activities that are going on at the very limits of our universe that are back in time to the big bang formation of the universe itself. And connected with that is our own solar system we are studying—the close-in planets, the more distant planets, the more primitive bodies like asteroids and comets. We are studying the Sun itself and the relationship of the Sun to the Earth and the Earth's environment—so-called solar-terrestrial physics. We are studying the upper atmosphere and the magnetosphere and we are bringing all this down to life on Earth to remote sensing from outer space. We are very deeply involved in the science and technology of oceanography, of land use, of hydrology, of agricultural assessment, mineral exploration. We, of course, are involved in communications and other items that bear upon life here on Earth, so there's a great deal of linkage throughout the program.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
RESEARCH AND DEVELOPMENT BUDGET — FY 1984
(DOLLARS IN MILLIONS)



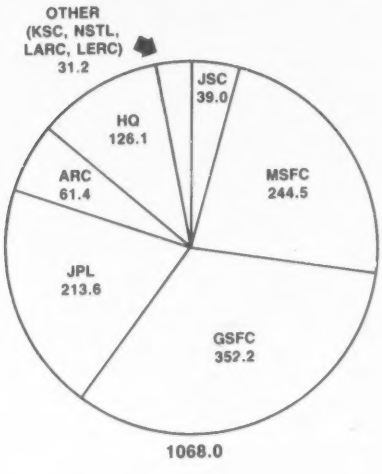
It's not quite possible to skip a discussion of financial aspects completely and I've chosen to show it in this way. On the lefthand panel, you'll see the space science and applications' budget for fiscal year 1984 (figure 5). The $1,068,000,000 shown there was the submission to the Congress and that has been increased by $68 billion—$68 million. So that the sum is in excess of $1.1 billion; so it is a very sizable program. Of course, we're never completely happy with the totality of the funds at our disposal, and we can always do more but, rather than complain about lack of funds, I would like today to say that we have a great deal of money and we are trying very hard to do as much as we can with that.

You'll notice that the pie on the left is split in two; a little bit more than half on the right is devoted to flight projects and not quite half on the left is devoted to what we refer to as the research base. The righthand half is characterized by rigid constraints in terms of dollar-funding, project schedules, cost control. We have management of that half of the pie which is very strong on engineering, project management and program control. The lefthand side of the pie, referred to as research and analysis; mission operations and data analysis and some of our suborbital programs, on the other hand, are characterized by level-of-effort activities.

There is some flexibility in the lefthand side of the pie and managers like myself have to be eternally watchful to see that we don't eat into our feed corn; that we don't gobble up some of the lefthand side and destroy our research base by problems and overruns or difficulties that occur with the flight projects; so, it's very difficult to keep the two balanced together.

OFFICE OF SPACE SCIENCE AND APPLICATIONS BUDGET DISTRIBUTION BY CENTER

FY 1984



E-6

On the righthand chart (figure 6) is the same amount of money showing how the science and applications money is distributed among the centers. I think mine is the only office which provides funding to each of the NASA centers. It probably would not surprise you to see that a third of the money is going to Goddard and about a quarter of the money—about 20 percent of the money going to JPL. You might be surprised to see that as much as—just almost a quarter of it is going to the Marshall Space Flight Center and that's because of the fact that we have a number of shuttle payloads supported there and, of course, we have the space telescope project there and a number of other projects. But, indeed, we do have significant and healthy programs at Ames, at Johnson and, as I say, at each of the centers.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
BASELINE PROGRAM

MISSION	IN OPERATION	IN DEVELOPMENT	START FY 1984
EARTH SCIENCE AND APPLICATIONS			
LANDSAT-4	X		
INTERNATIONAL SUN-EARTH EXPLORERS (ISEE)	X		
NIMBUS-7	X		
DYNAMICS EXPLORER	X		
INTERPLANETARY MONITORING PLATFORM	X		
SOLAR MESOSPHERIC EXPLORER (SME)	X		
EARTH RADIATION BUDGET EXPERIMENTS (ERBE)		X	
ACTIVE MAGNETOSPHERE PARTICLE TRACER EXPLORERS (AMPTE)		X	
COMMUNICATIONS			
APPLICATIONS TECHNOLOGY SATELLITES (ATS) 1 AND 3	X		
ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE (ACTS)			X
SHUTTLE PAYLOADS			
SPACELABS 1, 2, 3, 4		X	
SOLAR OPTICAL TELESCOPE		X	

E-7

OFFICE OF SPACE SCIENCE AND APPLICATIONS
BASELINE PROGRAM

MISSION	IN OPERATION	IN DEVELOPMENT	START FY 1984
ASTROPHYSICS			
SOLAR MAXIMUM MISSION	X		
INTERNATIONAL ULTRAVIOLET EXPLORER (IUE)	X		
INFRARED ASTRONOMY SATELLITE (IRAS)	X		
SPACE TELESCOPE		X	
GAMMA RAY OBSERVATORY		X	
COSMIC BACKGROUND EXPLORER (COBE)		X	
ROENTGEN SATELLITE (ROSAT)			X
EXTREME ULTRAVIOLET EXPLORER (EUVE)			X
SOLAR SYSTEM EXPLORATION			
PIONEERS 6-11	X		
PIONEER VENUS	X		
VOYAGER 1 AND 2	X		
GALILEO		X	
INTERNATIONAL SOLAR POLAR MISSION		X	
VENUS RADAR MAPPER			X

E-8

Now, shown here are these two boards (figures 7 and 8) are our ongoing programs. These are all approved programs. I won't go into them in any detail whatsoever—just to point out to you that we have programs alive, well, ongoing in each of these program areas. We have some in orbit, as shown in—with the little X's

under in operation. We have some in the stage of development as shown by the next vertical column of X's and we have several which we are planning to start in fiscal year 1984.

Now, these are all approved projects in the various categories and it shows that we have a very healthy base to start from in our planning and, of course, we are interested in continuity, in programs and in scientific area. We are interested in the heredity of one program to another and we are interested in striking out in some new fields, but with a balance of carrying through on previous commitments. It's a very wide-ranging program in terms of discipline areas and, as I've said, between the linkage from the edge of the universe to life on Earth. So, that it's difficult to balance it off and it's not an easy task to do planning.

POTENTIAL NEW MISSIONS

	PROPOSED NEW START YEAR
UPPER ATMOSPHERE RESEARCH SATELLITE (UARS)	1985
PLANETARY OBSERVERS	1985
OCEAN TOPOGRAPHY EXPERIMENT (TOPEX)	1985
SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF)	1986
COMET HMP RENDEZVOUS	1986
ORIGIN OF PLASMAS IN EARTH'S NEIGHBORHOOD (OPEN)	1987
ADVANCED X-RAY ASTROPHYSICS FACILIITY (AXAF)	1987
GEOPOTENTIAL RESEARCH MISSION (GRM)	1988
SOLAR DYNAMICS OBSERVATORY (SDO)	1988
GRAVITY PROBE-B (GP-B)	1988
SYSTEM-Z	1989
GEOSTATIONARY PLATFORM	1989

E-9

The chart (figure 9) which you see displayed now is the result of a great deal of effort, of anguish, of concern. There were those even in our own office who suggested that we not reduce such a plan to writing at all but, now that we've done so and displayed it to our various advisory committees; argued it out among ourselves, we are very pleased that we have it. It's not written in stone, but it will take good arguments to change it. It shows the new start—this is our 5-year plan—it shows the new starts that we are working toward and will plan to request of the administration and of the Congress as shown here.

We are planning now—as you know, we've not submitted our fiscal 1985 budget and so I'm quite free to speak about it—we are planning to submit three new starts in fiscal year 1985. The Upper Atmosphere Research Satellite, the Planetary Observer, as a class, and the Ocean Topography Satellite. I'll speak about each of these in just a moment. Then, we have two in 1986, two in 1987, three in 1988, and two in 1989. The order of these was arrived at after a

great deal of study, analysis, argument—even in one case we had a vote of the planning council to try to break a deadlock on arguments.

There are 12 missions shown here and we started with about 30. One of the problems is that NASA has had, in its long-range plan in the past, a great number of missions which were being advocated by small groups—by the various centers or by a program office in NASA—and they didn't have the blessing of the administrator or the general management and little groups were promoting them and it was almost up to the viewgraph person—person who drew the viewgraph as to what date he would put on it as a proposed new start. Well, we've hammered on this list and here it is. These are our major new starts. I will point out only that the two listed in 1989—the System-Z, which is a polar orbiting, remote-sensing spacecraft—kind of a successor to both Seasat and Landsat and the geostationary platforms are an intrinsic part of the space station program. They are wonderful, viable, useful programs which we will pursue as part of the space station program if NASA gets a space station program.

They are not doable without a space station and, with a space station, they are doable. It makes an important point which I will try to make in a few minutes again, and that is that the decision which NASA has made to include space station missions along with a space station manned base is a very important one.

FUTURE EXPLORERS	PROPOSED START DATE
HIGH Z EXPLORER OR LONG DURATION EXPOSURE FACILITY-2 (HIZE OR LDEF-2)	1984
X-RAY TIMING EXPLORER (XTE)	1986
PLANETARY OBSERVERS	
MARS GEOSCIENCE/CLIMATOLOGY ORBITER	1985
LUNAR POLAR ORBITER	1988

FUTURE SHUTTLE PAYLOADS	PROPOSED START DATE
SPACE PLASMA LAB (SL-6)	1984
HIGH ENERGY ASTROPHYSICS LAB (OSS-2)	1984
EARTH OBSERVATION MISSION	1984
BIOMEDICAL LAB-2 (SL-10)	1985
MICROGRAVITY LAB (SL-8)	1985

E-11

We have other projects (figures 10 and 11) which are in classes such as explorers and the new class of planetary observers and the shuttle payloads for which we do not get explicit new-start approval but which are defined and planned and approved in the same way and, in our Explorer program, we plan to get started on the High Z Explorer. That's a long-duration exposure facility, and the X-ray Timing Explorer in 1984 and 1986 respectively. We have Planetary Observers as a class. Two of those—I'll be speaking about those in a minute. And we have a number of future shuttle payloads that we will pursue in order to make optimum use of the space shuttle. These are spacelab type missions. We are trying to get away from the use of initials only. I think some people have been confused by our calling them OSS's and OSTA's and so on, the initials of which don't stand for anything any more. So we are starting to call them—for example, the astrophysics lab and biomedical lab.

Now, this series of charts which represents our—is a summary of our 5-year plan. The major new starts: Explorers, Planetary Observers, and shuttle payloads, and that's it.

UPPER ATMOSPHERE RESEARCH SATELLITE PROGRAM

OBJECTIVE:

TO UNDERSTAND THE COUPLED CHEMISTRY DYNAMICS, AND ENERGY INTERACTIONS OF THE UPPER ATMOSPHERE AND THEIR VARIABILITY.

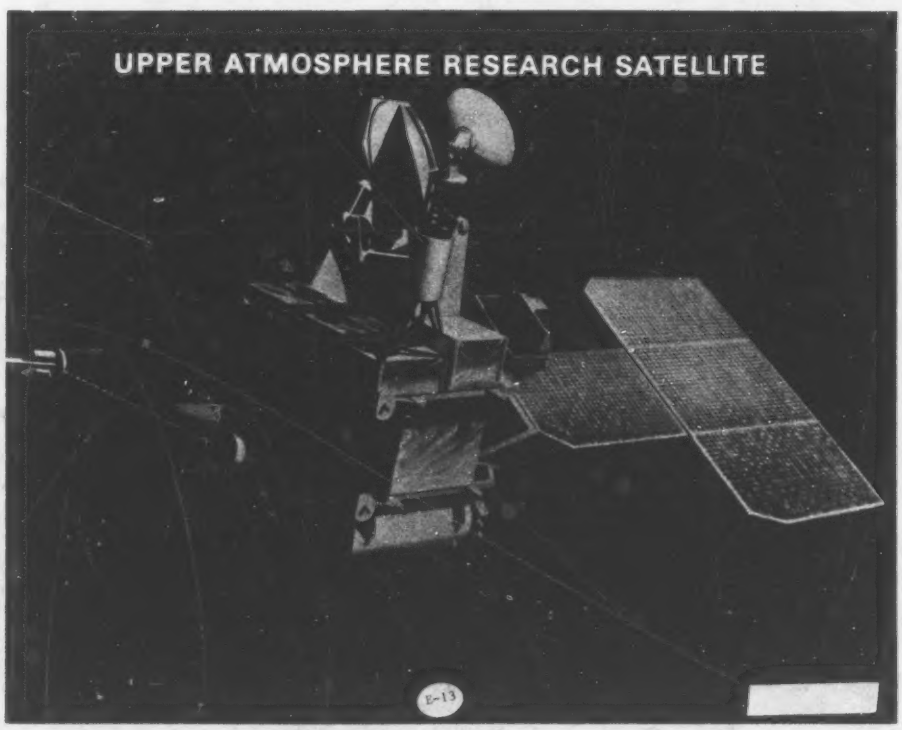
CHARACTERISTICS:

- MEASUREMENTS OF CHEMICAL COMPOSITION, TEMPERATURE, WINDS, AND SOLAR INPUT.
- 57° INCLINATION, 600 KM ALTITUDE ORBIT.
- NINE EXPERIMENT INVESTIGATORS, 10 THEORETICAL INVESTIGATORS SELECTED NOVEMBER, 1982, AND TWO "TARGET OF OPPORTUNITY" EXPERIMENTS.

STATUS:

- UARS EXPERIMENTS LINE WAS FY 82 NEW START.
- PROPOSED MISSION NEW START FOR FY 85; LAUNCH IN FALL 1989.
- INSTRUMENT ADVANCED DEFINITION PHASE COMPLETED FALL 1982.
- SOME INSTRUMENT EXECUTION PHASE CONTRACTS COMPLETED, OTHERS IN FINAL NEGOTIATION PROCESS.
- PHASE B MISSION DEFINITION STUDY TO BE COMPLETED FALL 1983.

E-12



I think I'd like to flip through the rest (figures 12 and 13) of these very quickly without further reading the charts or—I guess you really can't see the pictures very well, but the Upper Atmosphere Research Satellite is our major new—No. 1 priority for fiscal year 1985. It is a program which you might say is half-authorized. We were authorized to start on the instruments some years ago—I think it was 1982. And we are starting on—we are asking now to go ahead with the satellite itself in fiscal year 1985. It is program-aimed at understanding the very important chemistry of the upper atmosphere and the dynamic coupling and energy exchange at that level. It is an extremely important part of our global habitability program and we intend to support it very strongly.

PLANETARY OBSERVERS

OBJECTIVES:

TO ESTABLISH A LEVEL-OF-EFFORT PROGRAM (SIMILAR TO EXPLORER PROGRAM) CONSISTING OF LOW-COST, MODESTLY SCALED INNER SOLAR SYSTEM MISSIONS.

CHARACTERISTICS:

- INNER SOLAR SYSTEM.
- FOCUSED SCIENCE.
- LOW-COST, SIMPLE VEHICLES WHICH ARE DERIVATIVES OF EARTH ORBITERS.

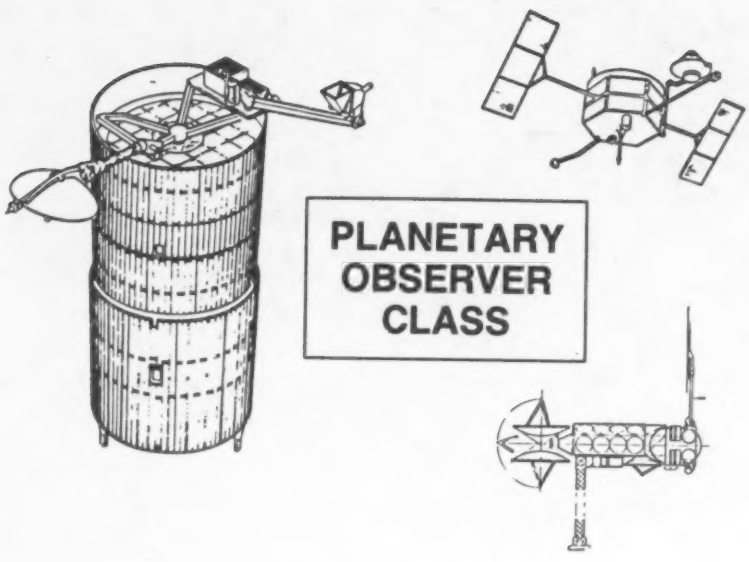
CANDIDATE MISSIONS:

- MARS GEOSCIENCE/CLIMATOLOGY ORBITER.
- MARS AERONOMY ORBITER.
- MARS PROBE NETWORK.
- VENUS ATMOSPHERIC PROBE.
- LUNAR POLAR ORBITER.

STATUS:

- PRE-PHASE A/PHASE A STUDIES HAVE DEMONSTRATED FEASIBILITY.
- MARS GEOSCIENCE/CLIMATOLOGY ORBITER (MGCO) SELECTED AS FIRST PLANETARY OBSERVER.
- PLANNING AIMED AT FY 1985 INITIATION.

E-14



E-15

We've had very good success over the years with our Explorer program (figures 14 and 15). The Explorer program has been one in which we aimed at low-cost missions; we ran it at a level-of-effort, and I think it is now running at about close to $50 million per year, and we were able to phase in programs and they were science and technology driven rather than arbitrarily scheduled or cost driven. NASA had a great incentive to get absolutely the most for the taxpayers' dollars because we were dollar limited and we tried to configure programs to be low-cost and to get the maximum amount of science for the dollar spent.

Well, now, the Solar System Exploration Committee, about which you've heard, has recommended to NASA that we adopt the same philosophy for some of our planetary missions. Instead of going each time for a grand planetary mission with many instruments—a spacecraft which was as large and capable as possible in order to hold all the different instruments is to use maximum inheritance from existing spacecraft—in fact, the three spacecraft shown on the right are existing application spacecraft. Two of them are communications satellites and one of them is a remote sensing satellite. And we've done studies to show that they can be used for planetary science missions and so we'll ask in 1985 for authority to start a new class of planetary observers that will do for planetary science what the explorer class has been able to do for astronomy and physics and astrophysics. We've selected the Mars geoscience climatology orbiter as the first mission of this class and, if we get approval for the class, we will start on the Mars mission first.

TOPEX
(OCEAN TOPOGRAPHY EXPERIMENT)

OBJECTIVE:

TO DETERMINE THE GENERAL CIRCULATION OF THE GLOBAL OCEANS VIA MEASUREMENT OF THEIR SURFACE TOPOGRAPHY USING A SPACEBORNE ALTIMETER.

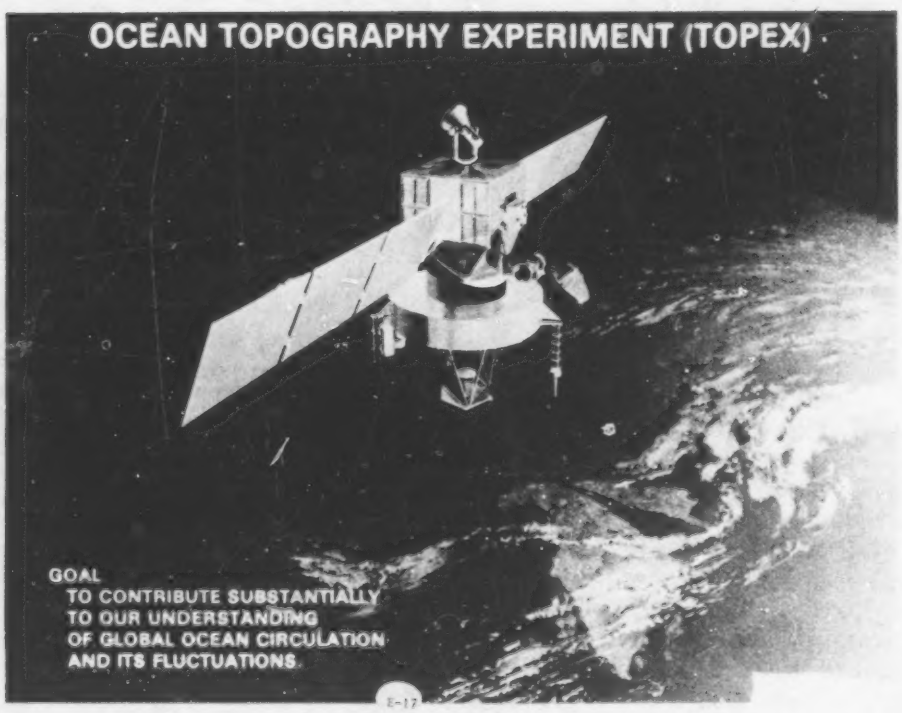
CHARACTERISTICS:

- DEDICATED ALTIMETRIC SATELLITE.
- 1300-KM ALTITUDE, 65° INCLINATION ORBIT, TO BE LAUNCHED BY ARIANE.
- PART OF WORLD OCEAN CIRCULATION EXPERIMENT.

STATUS:

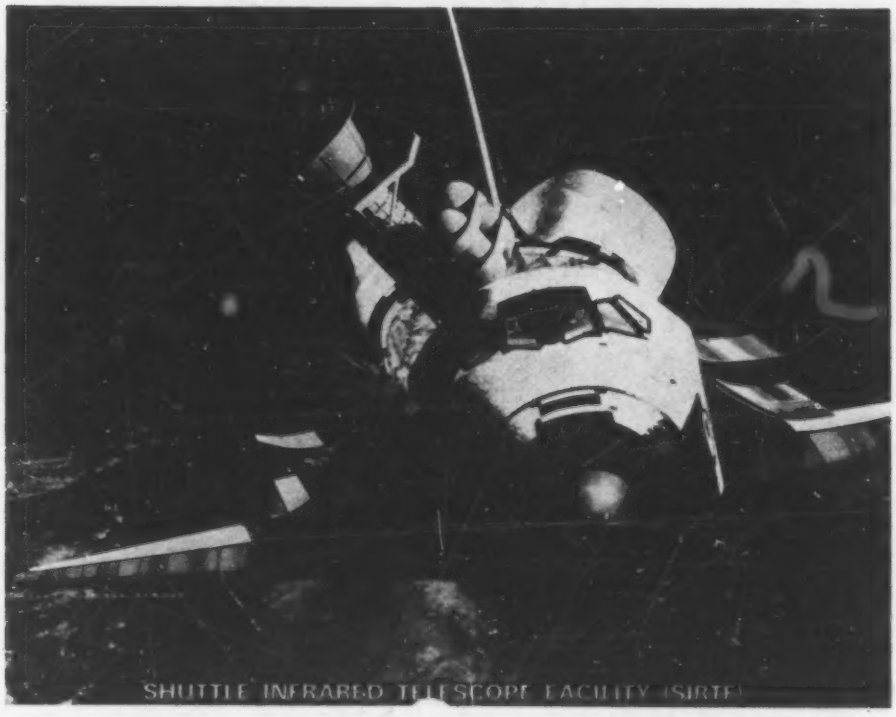
- PROPOSED NEW START FOR FY 85; LAUNCH IN 1988.
- MISSION NEEDS STATEMENT SIGNED.
- JOINT PHASE B STUDIES RFP TO BE ISSUED SHORTLY BY USA AND FRANCE.

E-16



The ocean topography experiment, known as TOPEX (figures 16 and 17), is also a very important part of our oceanography and thus

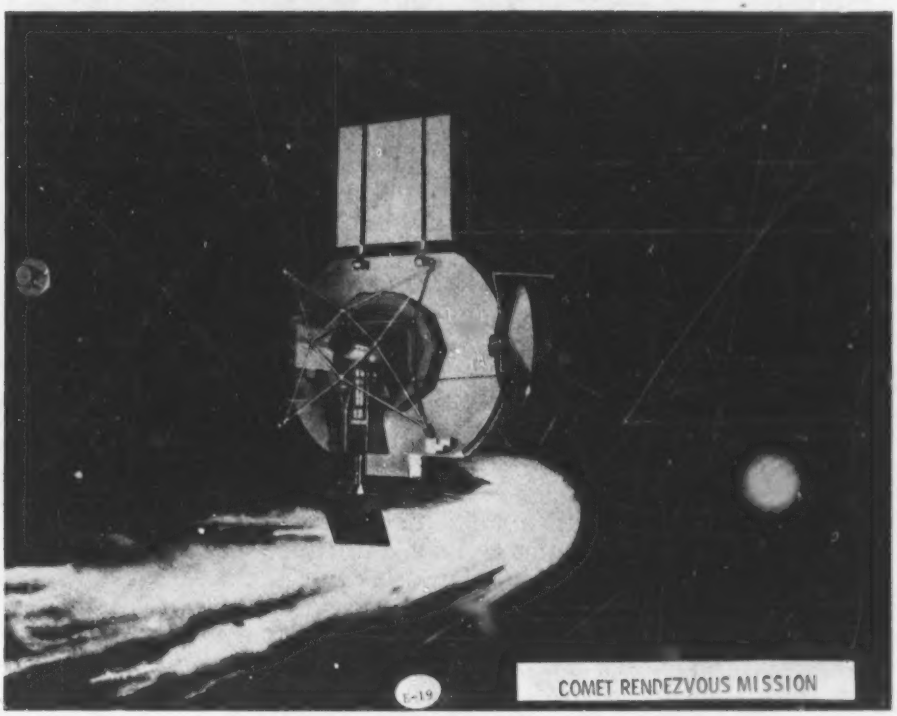
of our global habitability program. It is to fly a very extremely accurate radar altimeter to measure within a centimeter or so ocean height. It is a program of very great international interest and we are proposing to start on it in 1985. This is a program in which we have been discussing with the French space agency the possibility of a joint mission and, in fact, have recently agreed with the French space agency that we'll do a joint study of the feasibility of a joint mission—that is, flying some of their instruments on our spacecraft. And, so there's good possibility for cooperation there. In fact, that's what the last bullet on that chart says.



OK, I've covered the first three, the proposed 1985 new starts and I'll just mention some of the others. Next is—you want to put one up on the righthand screen. Yes, that's SIRTF (figure 18). That's the Shuttle Infrared Telescope Facility. It is to investigate the high sensitivity IR mission from various cosmic sources. It's very—it's gained in interest very much recently because of the enormous success of IRAS, the infrared astronomy satellite, which is even now making discoveries in the Heavens. The wealth of scientific data that's coming back to us from IRAS and the fact that it's worked out so well from a technical point of view—that the Dewar cryogenic system has been able to keep it at very close to absolute zero, using super fluid helium for a long time—in this case, a year—has created great enthusiasm for pushing ahead even faster with SIRTF.

We have recently entered into agreement with ESA, the European Space Agency, to look at cooperation between their infrared mission, ISO, and our mission, SIRTF.

We are considering the possibility now that we would fly SIRTF as a free-flyer or on a platform in addition to, or as an alternative to flying it on the shuttle for the first time. That's a study that's currently underway. Very exciting program.



The next one on the list is a comet rendezvous mission (figure 19). This is the first of the Mariner Mark II missions which were recommended by the Solar System Exploration Committee.

This would be intended to follow a complete perihelion passage of one of the solar system's more primitive bodies—comet. It would not be like the Halley missions which are all fly-bys. Those are just encounters —close encounters of Halley at really quite tremendous speed. This would be a rendezvous—a kind of a flying alongside by this particular spacecraft to make in situ measurements of the comet nucleus, its comet and its tail over a long period of time.

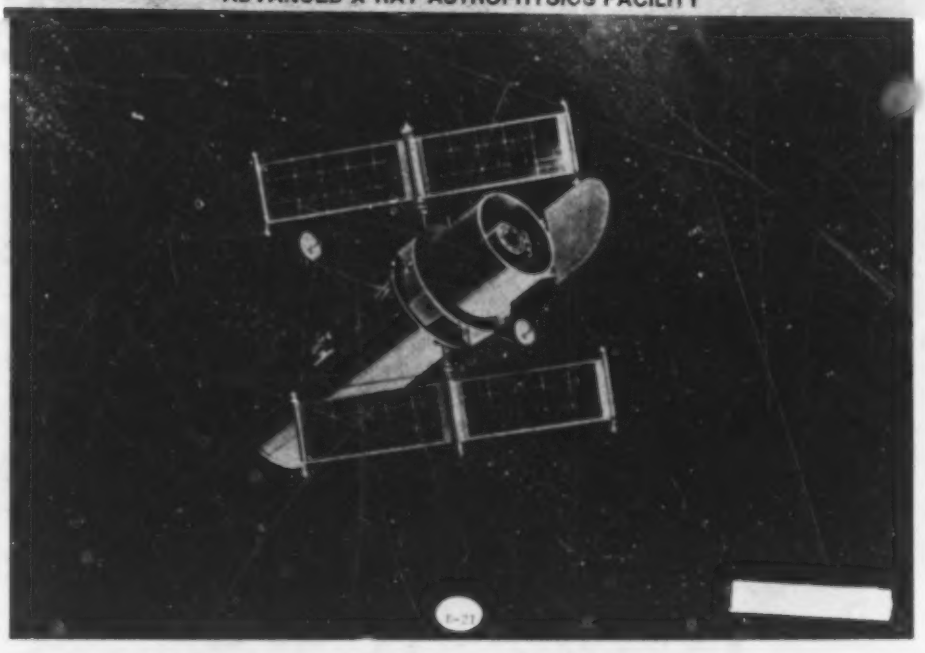
I perhaps misused—over-used the word "exciting" but this certainly is another very exciting mission.

The OPEN mission (figure 20), which stands for origin of plasmas in the Earth's neighborhood, is a multiple spacecraft mission. Shown are four of the spacecraft here. One is out at the—what is referred to as the nose of the magnetosphere, the blunt part that faces the Sun, shown there as IPL, one as —one in the tail of the magnetosphere, which follows the solar wind behind the Earth away from the Sun, shown as GTL, and then a polar orbiting and an equatorial orbiting spacecraft. This will make simultaneous measurements of particle radiation and magnetic and electrical forces simultaneously from the four spacecraft. It will make a very valuable contribution to solar terrestrial physics and, in the ESA meeting which I just referred to, which took place between NASA and ESA in June, there was so much interest in this program that we have decided to call a working group together of representatives of different countries—the United States the European nations and Japan—all of whom are proposing programs in the general solar terrestrial physics area.

And, since they are multiple spacecraft programs, it is very amenable to cooperation. We're trying to develop, with a savings to everybody, an increased scientific merit, an international solar terrestrial physics program which would involve not only these four spacecraft but other solar observation spacecraft as well. The thought is that maybe the United States wouldn't put up all four of these spacecraft. We would put up one or two and the Europeans might put up one or two and the Japanese might put up—I don't want to pick numbers, but some spacecraft from different countries and with instruments of very many countries. It's an outstanding program for true international cooperation—on a spacecraft level,

on the instrument level and on the investigator—what we call the co-investigator and science analysis level.

ADVANCED X-RAY ASTROPHYSICS FACILITY

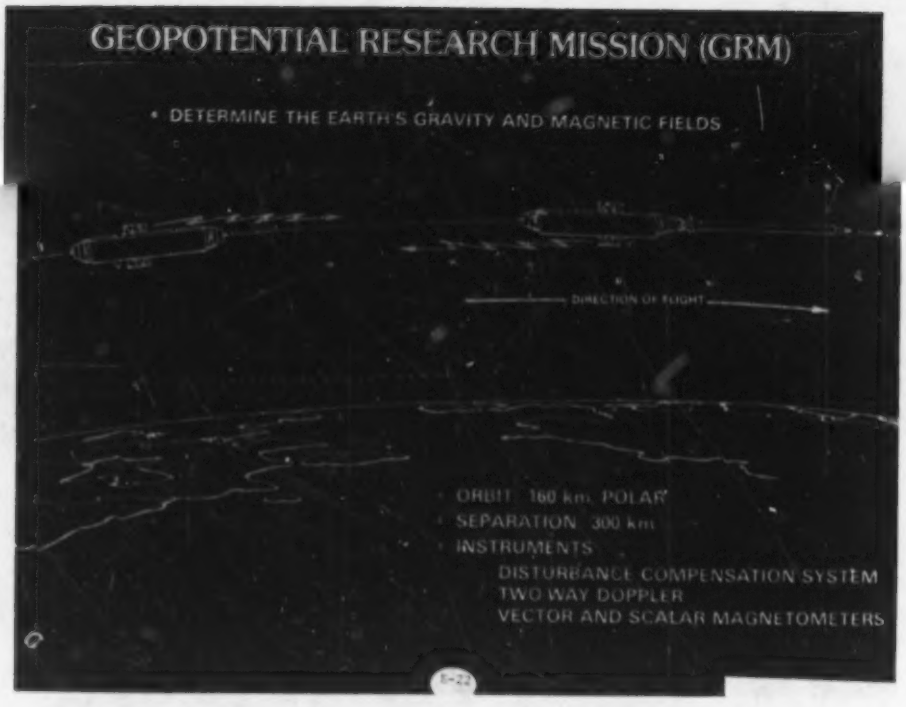


The AXAF, the Advanced X-ray Astrophysics Facility, shown in the next viewgraph (figure 21), was singled out by the Astronomy Survey Committee, the so-called field committee, as their No. 1 priority. Would you put the next one on, please?

That really is to do for X-ray astronomy what space telescope will do for optical observations. It is a major facility. It will follow on work that United States has led in X-ray astronomy. It will bring the United States back into a field of enormous importance and enormous opportunity for understanding of the distant universe and one that we will try very hard to push forward with.

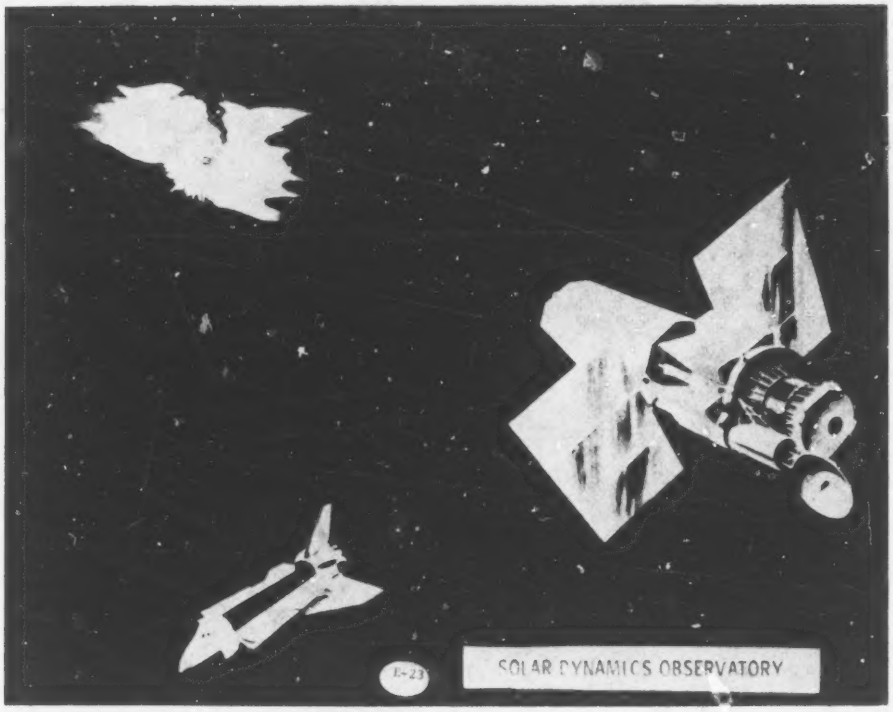
We've unfortunately had to delay starting this program a year. We originally had thought that we would start it in 1986; due to problems with the space telescope, largely, we've had to delay the start of this program but we will push it as soon as we can.

I think I'll do no more with the rest and let you look at the viewgraphs of each one, one at a time.

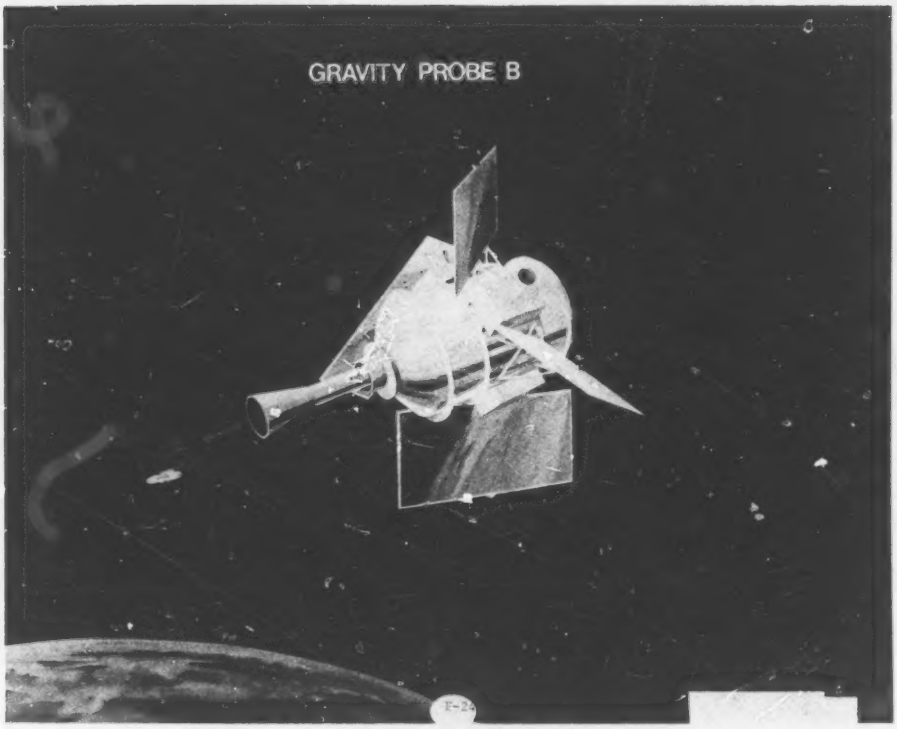

GEOPOTENTIAL RESEARCH MISSION (GRM)
• DETERMINE THE EARTH'S GRAVITY AND MAGNETIC FIELDS
DIRECTION OF FLIGHT
• ORBIT 160 km, POLAR
• SEPARATION 300 km
• INSTRUMENTS
DISTURBANCE COMPENSATION SYSTEM
TWO WAY DOPPLER
VECTOR AND SCALAR MAGNETOMETERS

Let's try the next one, please.

This is the geopotential research mission (figure 22), which is known as GRM. It is of very great importance and, as a matter of fact, is very closely coupled scientifically with the TOPEX mission. We wish we could afford to do both of them at the same time, but we can't. But we will bring GRM along as fast as we can.

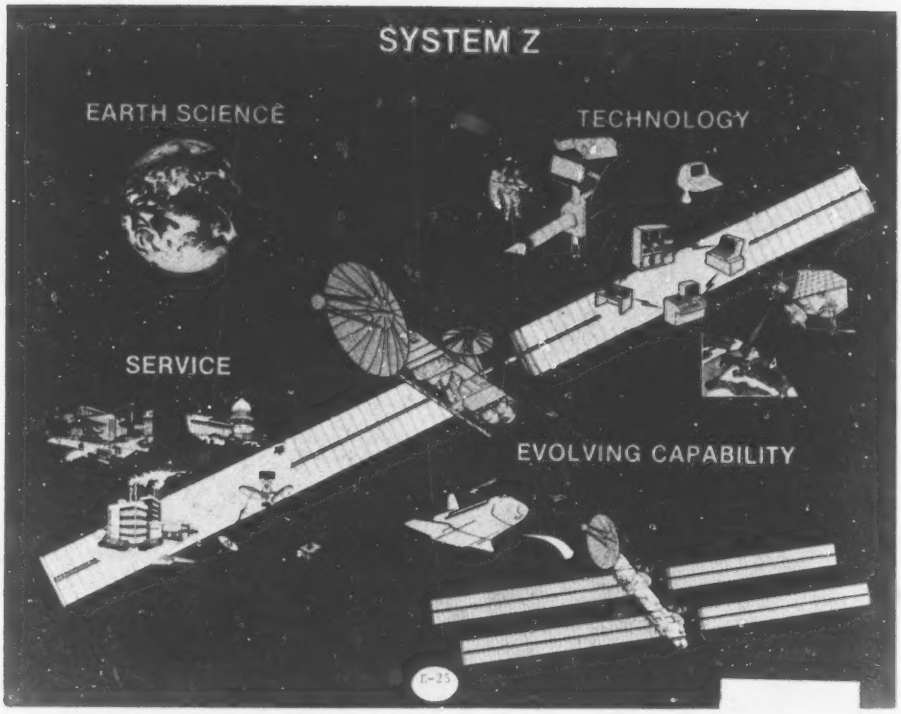


Next is the solar dynamic observatory (figure 23,) which is one of the spacecraft that might be folded into the OPEN mission—I should say "folded into the international solar terrestrial Physics program about which I spoke a moment ago." If we can do that, it will disappear as a separate project and will be folded in with one of these other projects.

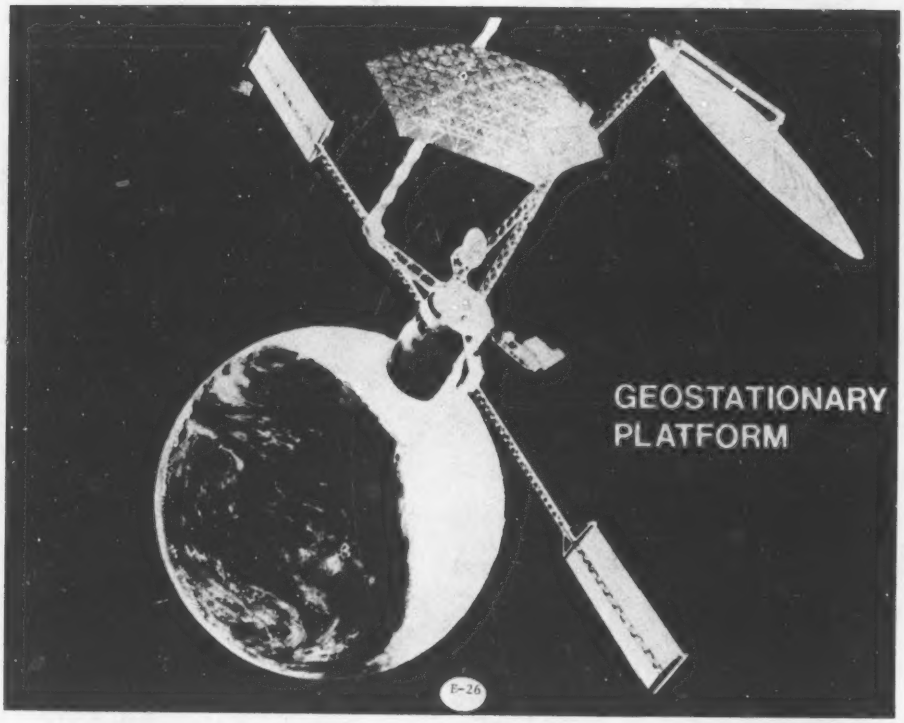


Gravity probe B—next viewgraph, (figure 24) please—is in many ways one of the most important projects that could be undertaken in the space program. The community we would serve here is not the usual space science community, but gravitational or relativity community and we would be looking here for a unique corroboration of a facet of Einstein's relativity theory that cannot be demonstrated in any other way, we believe.

It is scheduled for as far out as 1988 only because it is an extremely difficult technical mission, one which we do not yet have the temerity to plunge into at this time. On the other hand, if it were easy to do, it would have probably been done by now or you wouldn't require NASA to do it.

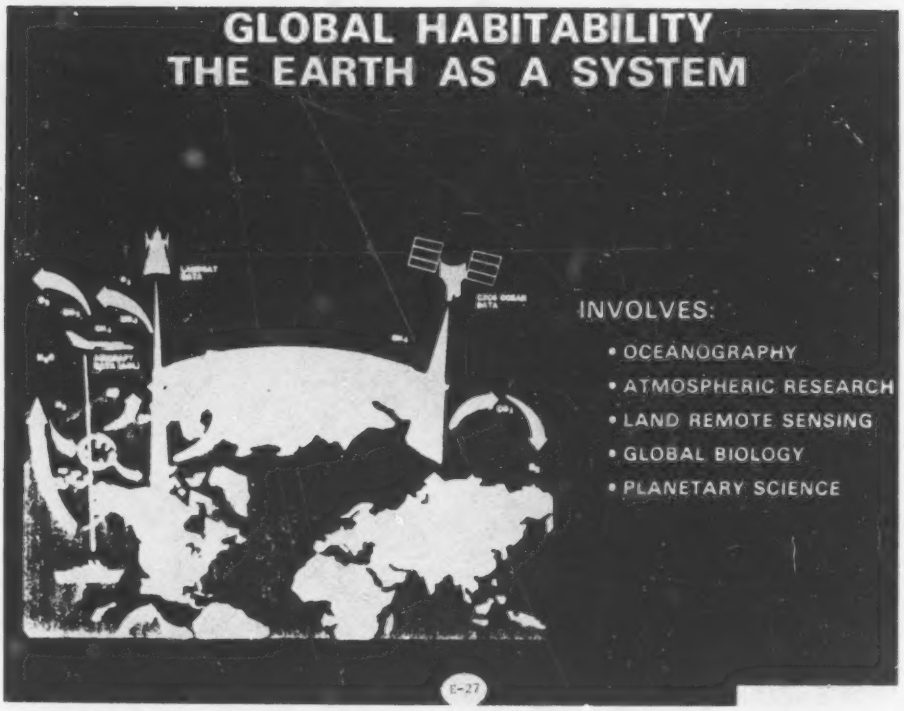


And, lastly, just to flash them on the screen, system Z (figure 25) is a concept of a space-station related mission. It is—the thought is that, if you put a number of different instruments—optical IR sensors and radars of different kinds and different frequency bands across the electromagnetic spectrum on the same platform, there would be a great deal of economy of scale; there would be a great deal of synergy between instruments and synergy between missions and we are studying this very intensively now and will propose, as part of NASA's space station effort, that we develop something along the line of what we're now calling system Z. As soon as we have it configured more definitely, we'll give it a better name than system Z.



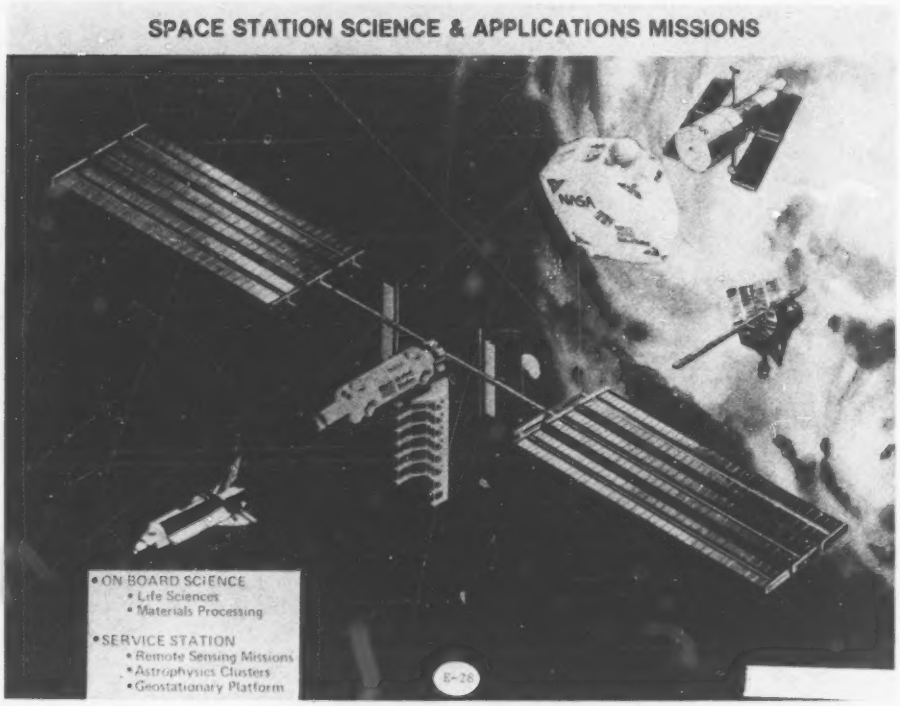
And, finally, on that list: the geostationary platform (figure 26) is the ultimate communications satellite. It's been recognized that there are great economies and a great performance potential and very large platforms in geostationary orbit. It's of great commercial interest. It's of great military interest and it's of great civil-governmental type of interest to have large apeurture, narrow beam capability in geostationary orbit, the kind that can only be got with a very large platform. We are talking about antenna, apeurtures of as much as 20 meters or even more. And these would be particularly useful for mobile communications—land, sea, and air mobile communications—and broadcasting of all kinds. And so, as soon as we have space-station staging capability in low earth orbit, we can start assembling and using these geostationary platforms.

Next, please.



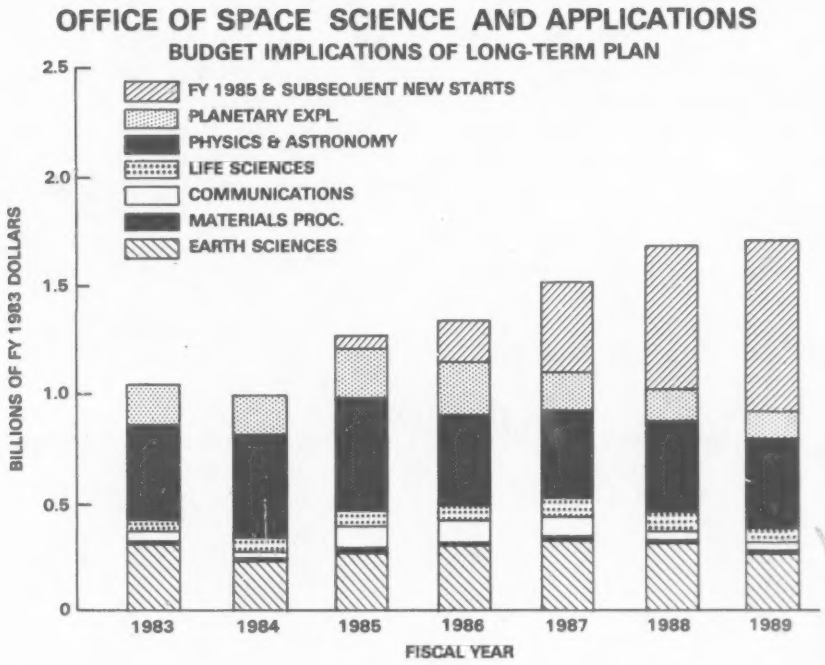
I'd like to emphasize now that, although it doesn't appear as a line item on our chart (figure 27), we are very much involved in pushing the Global Habitability program which is to treat the earth as a system. It involves, as the viewgraph says, oceanography, the atmospheric sciences, land remote sensing; there's a big biological input and even some planetary science involved in Global Habitability. It is a unique inter-disciplinary effort. It's the first NASA program—and, as far as I know, the only major program that mixes together the biological and physical science in a major system program. I hope that you'll be hearing a great deal about this in future years. This will probably be a ten-year program as an umbrella and it will include projects like UARS, TOPEX, Landsat, and so on.

Next, please.



I would like to emphasize that the Office of Space Science and Applications is very deeply involved in NASA space station planning effort (figure 28). We see essentially four requirements for science and applications as these requirements have been developed internally at NASA. We've had special studies done at Goddard at JPL. We've had our advisory committees within NASA look at the requirements. We've asked the Space Science Board and the Space Applications Board. We've been in touch with Department of Defense and we've come up with these other four requirements:

On-board science, which is life sciences and materials processing—would be done on the manned space station base. And then we would use the servicing capability of the space station to perform supporting functions for the system Z polar orbiting platform or a cluster of astrophysics spacecraft and platforms in low-inclination orbit; and, as a staging base for geostationary platforms and, in fact, for the kind of major planetary missions that we might attempt in the next decade.



OK and finally, just to show you what the effect of this would be on the budget—last chart, (figure 29) please, we are—if we were to add up our budget over the years, you'd see the cross-hatched area at the top for all of our new initiatives which I've just mentioned and the lower part of the chart ending up with planetary exploration; at the so-called dotted-part near the top is our runout program. Mr. Beggs, when he testified on Tuesday, mentioned that he thought something like 30 or 40 percent increase in funding would be required for NASA to carry out this overall plan, and I think science and applications fits in that same ballpark for the next 5 years.

Thank you very much, Mr. Chairman, for the opportunity to present this plan to you.

Mr. VOLKMER. Thank you very much, Dr. Edelson. Before we begin with questions, I'd like to recognize the ranking minority leader of the full committee, Mr. Winn from Kansas, for a profuse statement.

Mr. WINN. Thank you very much, Mr. Chairman, I appreciate the opportunity to introduce to the subcommittee Miss Elizabeth Camel of Prairie Village, Kans., Shawnee Maiden East High School, who has been selected as one of the 10 finalists in third space shuttle student involvement project competition. All those 10 regional winners are here, the finalists are here in Washington meeting with NASA officials. The objective of the project—involvement project—is to stimulate the study of science and technology in grades 9 through 12 by engaging students in a competition to develop payload experiments to be flown aboard the space shuttle. Elizabeth will have her experiment scheduled to fly on a future

space shuttle mission. She doesn't have ants, by the way. Although details about this aspect of the project have not yet been arranged.

I'd like to also introduce her instructor, Rick Gould, who is accompanying her on this trip. Let me just give you just a little bit about her experiment. It's called immunological reactions in zero gravity. The objective of this experiment is to evaluate the degree to which immunological reactions are influenced by gravity. The attachment of red blood cells to specific antibodies are in a closed system which will be compared for zero gravity and gravity-influenced environments. And Mr. Chairman, I'd like to introduce Elizabeth Camel to the committee at this time. Standing back here in the corner and Rick Gould——

Mr. VOLKMER. Raise your hands so we can all—thank you very much and let's welcome——

[Applause.]

Mr. WINN. Thank you very much, Mr. Chairman.

Mr. VOLKMER. Well, that's quite all right and I think you're right to be very proud of your constituent and we welcome her to the committee hearing. At this time I recognize the gentleman from New Mexico for any questions that he may have for Dr. Edelson.

Mr. LUJAN. Thank you, Mr. Chairman. As you were describing the global habitability project, you were talking about it being on a space platform or space station or whatever.

But I don't see why that could not be done by hanging an additional instrument on a Landsat or something like that. Is it necessary to have it on a platform, in the event that that doesn't come about?

Dr. EDELSON. Well, no, that may be a misinterpretation of what I was trying to say. The global habitability is not one spacecraft or one project. It's an umbrella program which covers a range of projects that we will pursue. Some on spacecraft which are free flyers and some on spacecraft which are attached to the shuttle, and some of which will, as System-Z, be involved with a space station program. For example, TOPEX and UARS are, in fact, separate spacecraft.

Mr. LUJAN. That's different from what I had understood that you were talking about, the various instruments to be on a platform or on a space station, whatever it may be.

Dr. EDELSON. Different ones, yes.

Mr. LUJAN. I don't have any questions, Mr. Chairman, I think Dr. Edelson has explained it very well and looks exciting, looks like we have a good program going. If the 30 percent comes up, why, that's the acid test, huh, of how bad do we want those programs?

Dr. EDELSON. That's correct, sir.

Mr. VOLKMER. At this time I recognize the gentleman from California, Mr. Brown. Do you have any questions for Dr. Edelson?

Mr. BROWN. Dr. Edelson, I have no fault to find with the content of the program the best I can understand it. But there's a lot I don't understand about it and a lot of it has to do with, a lot of my problems have to do with the level of effort which we're talking about here and timing. I'm not clear on these matters. I've just been at some hearings in the Agriculture Committee where we looked at the 6-year plan for the agricultural research service developed under assumptions of constant real dollars and the prob-

lems arise when you start setting priority between programs which have considerable value but there's some differences of opinion. I'm not sure whether you are assuming constant dollar budget or space science and applications or what the cost would be. Let me tell you specifically what that gets me to. You look at something like planetary science, for example, or planetary exploration and the figures show a declining program in that part of the chart labeled "Planetary Exploration." The next to the top dots going down.

Now, on the other hand, the planetary observers which would you label as a 1985 start are going to contribute to the planetary exploration program. But I'm not sure how much and what this means in terms of the ongoing health of the planetary exploration program in terms of knowledge. I don't think your chart reveals that. You probably have that information.

Dr. EDELSON. Yes; I do and I could have perhaps divided this up differently, Mr. Brown. Let me point out that the little dotted area that you're referring to which does in fact decline on here. That's what we refer to as our "Runout Budget."

Mr. BROWN. For the ongoing program.

Dr. EDELSON. That's the ongoing program. The ongoing program always declines in the future because——

Mr. BROWN. Not always.

Mr. VOLKMER. If the gentleman is willing to yield, maybe I can try to see if I understand it, the way Dr. Edelson is trying to present it. If so maybe I'm wrong too. Maybe I don't understand any better than the gentleman from California.

The part at the very top for the new starts. Is that reflected in the graph below the new starts?

Dr. EDELSON. No it's not. That's the answer to Mr. Brown's question that all the new things that we hope to do in solar system exploration are in that cross-hatched area.

Mr. BROWN. But it's not clear how much of each is in that area.

Dr. EDELSON. No, it's not clear from this.

Mr. VOLKMER. Could you give us a breakdown of that? In other words, how much of that is planetary, how much of that is communications, physics, and astronomy in the new starts? Not right now—but, could you furnish us with that.

Dr. EDELSON. Yes, sir.

Mr. BROWN. This is responsive to the point that I made that I wasn't sure whether this was a constant dollar or a real dollar budget. I would say that what you presented on that bar chart is pretty close to a constant dollar budget, assuming that inflation is about equal to the rate of increase in the——

Dr. EDELSON. Well, I'm sorry to have to interject at this point that it's in fiscal 1983 dollars.

Mr. BROWN. All of that's in fiscal 1983 dollars. It's just projecting a fairly substantial increase.

Dr. EDELSON. Oh yes, yes. That's a substantial increase. I think, to answer your question specifically, all of the increases that we are asking for and that I described on these various charts are in that cross-hatched area. That is a substantial increase. The failure to get any new money will bring us down on this descending line in constant dollars.

Mr. BROWN. Well, the charts that you have labeled "Potential New Missions" and "Proposed New Starts Each Year" doesn't have any dollar figures attached to it and you've reflected those in the bar chart over here but I'm still not clear how you would cost out each of these over the years. I'm sure you have that information and I think the committee would like to have it even though we recognize that these are planning figures and don't have other validity.

Dr. EDELSON. Yes. Recognizing that they are planning figures over a very long period of time, I'll do my best to separate them at least by areas, like how much for planetary, how much for physics and astronomy and so on.

Mr. BROWN. Well, that would be very helpful. There's a couple of areas that I have a special—well, I have a special interest in most of them—but let me mention a couple. The planetary exploration program is important largely because I'm so close to JPL and they're involved in it and I've seen what's happening as a result of the decline in the program and the necessity to change the mission at JPL and to readjust the mix of scientific capabilities and some other things of that sort. But take a look at another one that you have there, the communication. You have a program for advanced communications research which I presume is what is meant by communications, that white block. It shows that that's going down. Again, I'm not clear about the exact figures, but I think the amount in this year's budget for the advanced communications research is what, $20 million?

Dr. EDELSON. Yes. It's $20 million in 1983.

Mr. BROWN. In 1983. It's going down in 1984, then it goes back in 1985 and then it goes down again in 1988 and 1989. It looks like it gets back down to about 1983 level in 1989 from the chart.

Dr. EDELSON. Well, we have one major program in that area, Mr. Brown. That is the ACTS program [advanced communication technology satellite]. That's one that was we asked for in authority in 1984. Congress was very generous to us and added money in 1983 so that it looks like there's a decrease there between 1983 and 1984. It really is just that we got some of the money earlier and allowed us to get started earlier and we shall. Now that white area that you're referring, that's the runout of the ACTS program which altogether is about $350 million. That particular program is in there of $350 million spread over those years. Any new communications program, and the only one that I showed today was the geostationary platform, would be in the cross-hatched area at the top.

Mr. BROWN. Well, again I'm not clear how much, but I, and I think that this is representative of the general feeling in the subcommittee, have been a little leery about what's happened in advanced communications research because we saw the development of communications satellites, we saw NASA contribute greatly to that program and drop out of communications research essentially, and get back in again. We're seeing what happens when they get back in again.

Dr. EDELSON. Yes, sir.

Mr. BROWN. Now, the question is. I think some question just whether you should ever have gotten out and I have some ques-

tions as to whether this is an adequate level of research in the light of the fact that there's no other agency that I know of doing research in this field. I think we have testimony, Mr. Beggs may have testified on this, that there will be something like $35 billion for communications satellites for the next 18 years.

You're proposing a research program that amounts to one percent of that budget essentially, $350 million. I have serious questions as to whether that's an adequate ratio of research, both basic and directed, toward a program that is going to result in $35 billion worth of commercial expenditures within the next 18 years and maybe more, as I suspect that's a conservative estimate. Now I'm just raising this question, I don't know whether it has an answer, but I think we need to examine it.

Dr. EDELSON. That's a very good question in an important area. We're very delighted with the opportunity to go ahead with the ACTS program. The ACTS program will, in one program, reestablish U.S. technological leadership in the very important field of satellite communications. We're really leapfrogging the technology into the next generation in that spacecraft in multibeam antenna technology and onboard switching and onboard processing on the spacecraft and the use of the 30/20 gigahertz band. All of those will put the United States back in a leadership position. There are other things—for a while.

There are other things that we could and should do, for example, a mobile communications, and broadcasting communications, and data collection communications. There's probably no end to the things that we might and could do. It's a question of balancing the program and emphasizing the proper areas. Just at the present time we're extremely happy with the ACTS program and we're spending all of our efforts and making sure that's a success right now.

Mr. BROWN. Well, this is part of a broader program—question of the degree to which NASA, in this case, and the Federal Government in general, should be involved in advanced research in areas which may have huge potential commercial applications and impacts on world trade in communications items. Not only this committee but other committees are looking at that problem and it's a policy question which no one person has the answer to. But in a simple case like direct broadcast satellite television where the market may end up being far larger than that $35 billion that I mentioned just for the cost of new satellites that are going to be launched. I don't think we're doing a great deal in trying to solve this particular problem, although what you're doing is applicable in a general way. I raise these questions not with the expectation that you'll answer them but because the subcommittee brought them up before and I continue to be interested in them. The area item has to do, again it is not clear to me from your presentation just where we stand on the question of the platform. You've got and you've described some activities that relates to geostationary platform, the need for large antennas in geostationary orbit. You've described the system-Z which is conceptual rather than detailed and how that relates to specific planning on the development of a space platform in near-Earth orbit is not clear to me at the present time. It may not be clear to you.

Dr. EDELSON. Well, I'll try to clarify later. Of course, we're talking about advanced plans. Within NASA we're the user agency, the launch vehicles that General Abrahamson develops, not only the expendables but the space shuttle are, at least within NASA are for the payloads, the science and applications programs that my office is responsible for pursuing. And so it is or so it should be, at least, with regard to the space station and so we are the focus for the space station utilization. It's been said many times that NASA should have very good, strong feelings as to how the space station would be utilized before we start the space station program. We've spent a lot of effort doing that and that effort has been concentrated in my office.

What I tried to say is that a major way in which the space station can be utilized is to service these very large multi-instrumented platforms. We think that's a very good, cost-effective and performance use of the space station and we are going to participate in that program by developing two such platforms: A polar-orbiting platform which we referred to as System-Z, and a geostationary platform for communications and other purposes which would be assembled and checked out and tested in low-Earth orbit before its boosted up into geo-orbit.

Mr. BROWN. Well, I think I understand a little bit better. I think what you're saying and I probably should have known this is that the decision to go ahead with a near platform really is, probably wouldn't appear as a new start or potential new mission in your budget anyway. You are a user of platform, not the developer of the platform.

Dr. EDELSON. That's correct, and as you know, NASA has not decided yet, and for good reason, how we will manage the space station program. We're managing it with a task force on which my office has representation at the present time and that is essentially to see that all ingredients are considered for the space station program before it's assigned to any office or any center.

Mr. BROWN. All right, I'm getting the picture now. Now why you don't have dollar numbers attached to the proposed new start so that we can guess at how much each year is going to be added. Looking at the bar chart, I would guess we're talking about something that starts in 1985 at about, what, $30 to $40 million and then doubles and doubles again in 1988?

Dr. EDELSON. Yes, sir. Yes, that's about right.

Mr. BROWN. Then you attach some dollars to those figures to help us make these guesses?

Dr. EDELSON. Well, what I can do is—you see, it's not exclusively new starts, there's augmentations of all kinds included, research analysis in the research base. What I will attempt to do is to break this up for you by areas, such as how much of this planetary, how much of it is physics and astronomy, how much of it is life sciences, applications and so on.

Mr. BROWN. That will help a little bit in understanding the program. As I said to begin with, I'm thoroughly supportive of the nature of what you're doing there. I'm not quite clear how this coincides with my own set of priorities, how much I'd like to see spent in each of these areas. I need a little more information to be able to make that decision.

Dr. EDELSON. Thank you, sir.

Mr. VOLKMER. The gentleman from Virginia.

Mr. BATEMAN. Thank you, Mr. Chairman.

Dr. Edelson, thank you for your testimony. It's been very interesting and very helpful, I'm sure, to all of us on the subcommittee. I've been reflecting on one of your viewgraphs that's entitled "Potential New Missions." If you assume there were to be budgetary constraints, should I assume that the priority for the new missions is as they are listed here, or is that something that would have to reevaluated in light of the dimensions of the budgetary constraints you might be faced with?

Dr. EDELSON. Well, the priority is, Mr. Bateman, as listed here, and it would be our intention to follow it to the letter unless there were countervailing technical, economic, or other reasons which changed it. I mentioned during my presentation that perhaps a couple of these missions might be combined. The OPEN Mission and the SDO Mission, for example, fit neatly together. We might combine them. But, for example, we are asking for three new starts in fiscal 1985. It's our intention to put them in this priority order. If the wisdom of OMB or the Congress is such as to deny us one of these, we would put that at the top priority for fiscal 1986 and so on.

Mr. BATEMAN. If you reach, each in turn, at the end of the strength——

Dr. EDELSON. Yes, sir. And that's what I refer to as the painful and difficult decision that we had to make to prioritize these. But now that we've done it, we're glad we did because everybody that we're involved with, our community is pleased to know where they're in the queue. The unhappy ones are the ones who are proposing programs that didn't make the queue at all. And there are more of those than there are ones that are here.

Mr. BATEMAN. Now that list of potential new missions is one which relates to the new Office of Space Science and Applications. So is there a master prioritized list of new missions for NASA overall?

Dr. EDELSON. No, there isn't, because each of the offices is organized differently. And, except for the budget that's submitted each year is the only time we have to face up to the relative priorities of the different offices.

Mr. BATEMAN. It simply reflects——

Dr. EDELSON. That's correct.

Mr. BATEMAN [continuing]. Your order of missions in this fashion; others may not have.

Dr. EDELSON. That's correct. Well, this particular treatment is amenable to my office. I'm not sure that it would fit properly with any of the other offices, but I'll let them speak for themselves.

Mr. BATEMAN. Well, at some substantial risk of seeming crass, I didn't see a very big slice of any pie at Langley Research Center and I have some particular affinity for that one. Is that because that center has not related in mission in recent years as strongly toward space applications as to other NASA folks?

Dr. EDELSON. Yes, that's true. Although we do have some funding there, it's much smaller than at other centers. Langley is one of the leading research centers. Their expertise is largely in other

areas, in aeronautics primarily, and so they get the major share of their funding from, well, Dr. Colladay will speak to that in just a moment, I'm sure.

Mr. BATEMAN. Well, in relative terms, is their role going to enlarge or be diminished in your area of space science and applications?

Dr. EDELSON. Well, the one area that I can think of off-hand where I've been talking to them recently is in the area of very large antennas—large space structures—and they have an outstanding capability there. When we get into this geostationary platform, that will be the center we'll come to for our large structures and, particularly antenna reflectors and feed systems and so on.

Mr. BATEMAN. Would this make it the very likely prospective candidate as to being the lead center in space station program if that goes forth?

Dr. EDELSON. Oh, I wouldn't attempt to answer that one, Mr. Bateman. [Laughter.]

Mr. BATEMAN. I can understand why you wouldn't want to answer that. [Laughter.] I hope you can likewise understand why I thought I'd sneak in the question there.

Dr. EDELSON. Good question.

Mr. BATEMAN. I believe that's all I have this afternoon, Mr. Chairman.

Mr. VOLKMER. Gentleman from Florida, Mr. Nelson.

Mr. NELSON. Well, there is one of these charts, Burt. It said something about sending them one of these satellites in their union and I would like to know what's that all about.

Dr. EDELSON. Oh, I believe that was the Topex view-graph and as I mentioned, Mr. Nelson, we have, we're proposing that as a new start in 1985. It's been a U.S. program that we have proposed for some time. But the French Space Agency, CNES, has a program that they refer to as Poseidon which has a similar mission. It's also a precision altimeter which they intended to fly on a spot bus on the ariane launch vehicle. They propose to us that we work together on a joint mission and we have agreed to study a joint mission. The joint mission as configured would be that we would fly the U.S. Topex spacecraft. This is developed by JPL with the U.S. instrument on board which is a very high precision altimeter, also developed by JPL, and with a U.S. tracking package on the Ariane launch vehicle. They would put it into the orbit that we require for the Topex mission. We would also fly on ours some hardware of the French, which is their own tracking package to provide precision orbital tracking, and some in a solid state amplifier for the altimeter. I gather it's the Ariane vehicle that——

Mr. NELSON. Of the total cost of the Topex, what percentage would that be the United States?

Dr. EDELSON. Well——

Mr. NELSON. Would it be fifty-fifty?

Dr. EDELSON. Well, essentially the deal is that it's our spacecraft and their launch vehicle. So, if you consider the cost of developing this spacecraft and the cost of launching a spacecraft—yes, it would be about six to one.

Mr. NELSON. All right, then why if we're developing the spacecraft and that's our cost, why don't we send it in our launch vehi-

cle? Our launch vehicle is a lot more reliable than theirs. But aside from that, why are we going to send it in a French launch vehicle?

Dr. EDELSON. Well, I wouldn't seem to prefer a French launch vehicle over the U.S. space shuttle, I simply wouldn't do that. We would—the idea would be that they would fly it free for us.

Mr. NELSON. You are making the assumption then that there's no space availability at that particular time. And what would be the launch in 1988. You're making the assumption that there would be space availability on the shuttle.

Dr. EDELSON. No; we're really not doing that, Mr. Nelson. This is—the fruits here to be gained are international scientific cooperation, scientific mission, and we're seriously aiming at international scientific cooperation and good international relations. It is—I wouldn't deny that the French would be very eager to get the recognition of having a U.S. satellite launched by an Ariane launch vehicle. They just suffered through the ignominy of their Exosat satellite which had been planned for the Ariane of being transferred to fly on the U.S. delta launch vehicle. So I think they would like to see that. But, the only financial advantage to us would be that we could get a free launch on the Ariane and presumably use that spot to get commercial revenue on the space shuttle.

Mr. NELSON. Did you say that this has been agreed to or this is presently under discussion?

Dr. EDELSON. We have agreed to study it.

Mr. NELSON. You've agreed to study with this object in mind, that the bill, the Topex and that you would launch it on Ariane.

Dr. EDELSON. Yes, sir.

Mr. NELSON. All right, then let me just give you a little editorial here. We deal in all of these things and we get a lot of witnesses who come before us and tell us the French are undercutting us because they are subsidizing it more than we will subsidize and we've got this cutthroat competition who's going to have the viable launch vehicle. In the name of international cooperation, I'm not so sure that, just in the name of international cooperation, we ought to be lending credibility to the French launch vehicle when in fact, if all the other things that NASA and other witnesses have told us is true about the cutthroat competition. So that would be a reservation that I would make for the record at this point and I would have a feeling, and I don't want to speak for my colleagues sitting at this table, but I have a feeling that there might be similar reservations expressed among the members of Congress.

Dr. EDELSON. Yes, sir.

Mr. VOLKMER. At this time we have a rollcall vote on it. At this time we'll recess until 10 minutes till.

Mr. WALKER. Mr. Chairman, I only had one question. I want to get my question in before we recess. I wondered about the commercialization of Landsat, whether or not there would be any anticipation of continuing Landsat R&D, even if the satellite systems themselves became commercialized.

Dr. EDELSON. Yes; I think there's been recognition of that, Mr. Walker. NASA's role, of course, is research and development. We would, in our planning, continue the research and development whoever operates the system. After all, another agency, now NOAA operates it. We still perform the research and development.

Mr. WALKER. Commercialization would make no difference to your agency with regard to proceeding ahead on date.

Dr. EDELSON. Right. From where I sit, NASA's role would be the same whether we were developing technology for another government agency or for a—if the system were to be operated by a commercial organization.

Mr. WALKER. Thank you, Mr. Chairman, I appreciate it.

Mr. VOLKMER. We're going to have to recess until probably 5 minutes to 3 or 3 o'clock. I understand there'll be another vote right after this vote. I'd appreciate it, Dr. Edelson, you could remain because we do have additional questions.

Dr. EDELSON. For me?

Mr. VOLKMER. Yes; can you still remain?

Dr. EDELSON. Yes.

[Break for vote on the floor]

Mr. VOLKMER. Order will proceed with the questions that perhaps, we'll soon have other Members back. We can have that second vote right away. I don't know how long it'll be. I have several questions here that concern me. Life Sciences, now, is that in the application part or in the science part?

Dr. EDELSON. Well, it's a separate budget line item in your area. We recognize that we do some science and some applications work in Life Sciences. It's not a distinction that we make, actually, within Life Sciences.

Mr. VOLKMER. Do you use it, but it's in the science part of your jurisdiction. That's what I'm getting at.

Dr. EDELSON. Yes, sir.

Mr. VOLKMER. This in relation to life in space or total biology formation of life, global or what?

Dr. EDELSON. Well, there are really three areas that might be roughly termed: biological research, medical research, and then medical operations. With regard to Life Sciences as opposed to every other part of my organization, we have an operational role. My office is actually responsible for all space medicine, so we're responsible for the health and safety of the astronauts in flight. The reason for that is NASA can't afford to have a number of different medical offices and since we have a critical mass of biological and medical scientists, we keep them together. So the program is really divided into biological science, medical science, and medical operations.

Mr. VOLKMER. So there's really, since the space science feature and application research has been combined, there's really been no change in Life Sciences.

Dr. EDELSON. That's correct.

Mr. VOLKMER. But in programing——

Dr. EDELSON. That's correct. That hasn't changed at all.

Mr. VOLKMER. Now, in the view-graph on the office, your office distribution by center on the budget, we see a headquarters budget of $126.1 million. Is this total management, or what besides management does that include?

Dr. EDELSON. Well, it's not management at all, really, because that's mostly R&D and funding. All you see here is R&D funding. These are for contract grants that are dispersed directly from head-

quarters. A lot of university research and so on, comes directly out of headquarters.

Mr. VOLKMER. OK. So that isn't management at all then?

Dr. EDELSON. No, sir.

Mr. VOLKMER. And that part is not reflected in this budget?

Dr. EDELSON. That's correct.

Mr. VOLKMER. That's just programing.

Dr. EDELSON. These are all what we call program money and it's all out of the R&D part of the idea.

Mr. VOLKMER. In the potential new missions that we have over here, that we're looking at. Are these in addition, I guess they are, like the future explorers we have in the second, third shuttle payloads, etc? So those would be in addition to such things as found on the spacelab and on the shuttle itself?

Dr. EDELSON. Right. There are really three pages here. The first page is our major new starts to which we'll come to Congress for a specific authority to start those projects. The second page contains explorers and planetary observers in which we don't get explicit authority for each project but merely authority for the class. We get budgetary authority for it. The last page are those shuttle payloads which are authorized by category rather than by each mission.

Mr. VOLKMER. In the major new missions parts, how much did the budget implication influence the decision of the starts, when to start? Or was that a consideration at all?

Dr. EDELSON. That was not a consideration in priorities.

Mr. VOLKMER. Is it a consideration in starting, when to start? I don't know by priorities if we mean the same thing?

Dr. EDELSON. Well, we——

Mr. VOLKMER. Well, let me ask you this. Are we saying then that AXAF is really a No. 7 priority? In the total realm of what we're trying to do?

Dr. EDELSON. Yes. Now in arriving at that priority, we considered three things: One is the science relevance to, the need for the science and how it followed existing programs. And second, the technological readiness of it. Some of these programs, we're just not ready to do because the technology—the advanced—what we call ATD, advanced technology development hasn't been done, or we haven't done Phase B studies and so on. The third thing is balance in the program. For example, it's recognized that NASA—you might say this is implicit budget considerations—we really can't start on a new major telescope program until we have space telescope under our belt.

Mr. VOLKMER. Is that because of the overruns?

Dr. EDELSON. I don't think we could have done it if we had no overruns. And certainly because of the overruns, it would be unconscionable for us to come in at the present time while we're in the middle of solving problems on one big major telescope facility and say, gee, we want authority to start another program of that scope and size and complexity at the present time.

Mr. VOLKMER. In other words, the delay in starting AXAF is because of the telescope, because of the technical, technology aspects of the space telescope, management problems with the space telescope, is that correct? Is that what you're telling me?

Dr. EDELSON. Yes, that's what I'm saying. I think perhaps in the back of our mind is the fact that it's an expensive program and even if we didn't have any problems it'd be difficult to get an expensive program. But a major consideration, as I say, was scientific and technical problems in getting started.

Mr. VOLKMER. Now, when will we start, let's say, Phase B to design work on AXAF?

Dr. EDELSON. AXAF is—there are really three areas in which we work in advance, and we're in fact starting all those this year. There's the announcement of opportunity for the instruments and we have the announcement of opportunity prepared and we hope to issue it next month, during the month of August. That goes out to the various experimental groups around the country, frequently universities, usually universities for development of the scientific instruments which will be the focal plane instruments that look through the telescope. There'll be cameras and photomoters and so on.

Second, is the phase B study which goes to the potential contractors, the major aerospace contractors who would like to build the AXAF. We planned to issue that in February 1983. Just last February. We are postponing that until this fall. Probably we'll issue it in October/November timeframe.

Mr. VOLKMER. Of this year.

Dr. EDELSON. Yes, sir. And then finally is what we call ATD, advanced technology development. We have actually started that. The AXAF will use a different kind of optical arrangement because it's using X-rays. We'll use what you call a grazing incidence type of optics, those which use both reflection and refraction of the X-rays. It's necessary to do some advanced technology development. We don't exactly know how to build a mirror like that right now. So we've started some reasonable size contracts. I think we're spending several million dollars, certainly less than 10 on the advanced technology for AXAF this year.

Mr. VOLKMER. Do we have any X-ray astronomy satellites in orbit that are actually functioning.

Dr. EDELSON. Well, we don't; the United States does not. There's a European Exo-satellite which we launched and in which we will participate in the analysis.

Mr. VOLKMER. The information will be available.

Dr. EDELSON. The information will be available. Also, there will be—we are participating in the German X-ray satellite known as Rosat which will carry under our explorer line item, Renkin satellite. The Japanese are putting up satellites. The concern that I suspect you've heard about, Mr. Chairman, is that the U.S. X-ray astronomy community—which opened up this field of enormous potential and from which we had very exciting experiments such as the HEAO series, the H-E-A-O, high-energy astronomical observatories—that community is now without their own U.S. facility. They're eager to get started on AXAF. I have 140 letters——

Mr. VOLKMER. They're worried about falling behind and not having——

Dr. EDELSON. Yes, sir.

Mr. VOLKMER. And let somebody else gain on what we——

Dr. EDELSON. And rightfully so. That's a very serious concern.

Mr. VOLKMER. Now, in the planetary observer program, the solar system exploration committee, known as the Hinners Committee, made their report and—are there any recommendations made in that that you didn't go along with or agree with? That you know of?

Dr. EDELSON. No; I feel confident that there are no recommendations buried in there. Of course, we participated in it. Dr. Geoffrey Briggs, who is the head of our Solar System Exploration Division, was, in fact, the executive secretary for the SSEC all during its 3 years under the chairmanship first of John Naugle, then Noel Hinners, and now Dave Morrison. They have made several recommendations of both planetary observers and Mariner Mark II and we're following through on both of them.

Mr. VOLKMER. I didn't see a Mariner Mark II in here.

Dr. EDELSON. The comet rendezvous mission is a Mariner Mark II. So they recommended first the VRM, Venus Radar Mission, which we're doing, starting in 1984; the Pioneer; the Planetary Observers, which we will ask for in fiscal 1985; the Mariner Mark II, the first one of which is the Comet Rendezvous Mission; and the Titan Probe, which will come along probably about 1989 or 1990. We're just beginning to study that one. We've recently agreed with the Europeans we'll try to do that one jointly.

Mr. VOLKMER. Will we be using a standard type of spacecraft on the planetary observer program?

Dr. EDELSON. Yes, we will. That's inherent in the concept.

Mr. VOLKMER. And will those be utilizing existing known type satellites?

Dr. EDELSON. Yes, they will.

Mr. VOLKMER. Make some modifications on them.

Dr. EDELSON. Yes. The three that I showed in that little sketch up there, one was a Hughes communication satellite, one was an RCA, remote sensing satellite, and the other was a TRW communication satellite.

Mr. VOLKMER. There won't be a great expense in developing a satellite in order to do those things?

Dr. EDELSON. That's correct.

Mr. VOLKMER. Now. Oh, yes, on the infrared telescope facility that you mentioned you may end up having that as a free flyer rather than on the shuttle. What additional cost would it be if we didn't go with the free flying?

Dr. EDELSON. Well, we're studying that right now. Of course, you've got to provide all the stabilization and housekeeping facilities, thermal control and stabilization, tracking telemetry, command control, positioning and orientation; all of those facilities on a free flyer that the shuttle provides. On the other hand, with a shuttle you probably would get maybe 5 days or so of observation time; even with an extended shuttle mission, 10 days of observation time. Whereas with a free flyer, you would—with one supply of cryogenic fluid, it would last perhaps 18 months. So if you take the cost per unit of data, or per scientific observation, the free flyer would be much more cost effective.

Mr. VOLKMER. Would it be—if the free flyer remained in GEO?

Dr. EDELSON. Yes, sir.

Mr. VOLKMER. So actually, if necessary, you could develop it so that you could even make it refuel and make it go along with that, if necessary.

Dr. EDELSON. Yes. That's a very good possibility and we would attempt to do that. That's, of course, one of the things the space station would aim toward doing.

Mr. VOLKMER. Habitability. How much will we be spending on developing the total program in the future, in the next 5 years?

Dr. EDELSON. I can't answer that question exactly, because it is not a single budget line item. What it is is part of the global biology program and the VARS, TOPEX, and other missions. If we added those all together, I'd say about $200 million a year would be the NASA direct contribution to the global habitability program. But then, this is a program that we're proposing to join with other agencies. There's a role for NOAA, Agriculture, Interior, National Science Foundation, and others. We will work them together with the National Academy of Sciences to try to come up with a U.S. program and other countries will participate as well. It will be a truly international program to face a major global issue.

Mr. VOLKMER. Now, we're talking global; are we talking about Earth or are we talking about universe?

Dr. EDELSON. Earth.

Mr. VOLKMER. Earth, that's what I thought.

Dr. EDELSON. It's Earth oriented. We've stopped at the upper atmosphere. In other words, there was some question, and, of course, scientists would support the idea that the upper atmosphere is connected to the magnetosphere and magnetosphere to solar terrestrial physics and so on. We're going to stick to Earth.

Mr. VOLKMER. OK. Dr. Edelson, this is true. From my own district, we've gotten many letters about NASA animal research and using animal research in life science and medicine. Can you assure us that all NASA experiments using animals in space are on the ground or conducted according to strict protocols that assure humane treatment of the animals?

Dr. EDELSON. Yes; I can, Mr. Chairman. We're very scrupulous about that. We also receive mail and expressions of concern. I personally, and I know other management folks, have looked into this in great detail and we are very scrupulous about it.

Mr. VOLKMER. In our report accompanying this year's reauthorization bill, we requested a study of Sun-Earth interactions and how you plan to work on that?

Dr. EDELSON. Well, that's generally known as solar-terrestrial physics. It's the connection of the solar effluents, in fact, solar internal dynamics. The effluents of the Sun and the solar winds and their effect on the magnetosphere and the interaction of these electrical and magnetic forces with the upper atmosphere. It's all connected together. We have a number of studies of that area already by National Academy of Sciences Committees. What we propose to do is to answer the question by collecting, distilling, and addressing the problem exactly with the result of all the studies ongoing and then relating that to our ongoing program, which I discussed during my presentation.

Mr. VOLKMER. Do we have any application in the new starts that you've listed? Are they all science?

Dr. EDELSON. The ACTS communication satellite is strictly an application mission. In the major new starts, both System-Z and geostationary platform, are specific application missions for remote sensing and communication, respectively. And then a number of the shuttle payloads, particularly the shuttle imaging radars, are very obviously, important application payloads. Then, in addition to that, we have an ongoing program in materials processing in space shuttle payloads which is all considered to be applications. The projects, such as UARS, and TOPEX, are of the type that are carried under the applications budget and are used both for applications and for science—hard to distinguish.

Mr. VOLKMER. Now, we've also provided funds in the authorization and in the appropriations for instrumentation in universities, and so forth, in the planetarium and geophysics areas. How is this money made available to the universities? How do they go about applying for it or what? How do they get it?

Dr. EDELSON. Well, the program which, incidentally, is under study and we're trying to expand through a special committee which has been chaired by Frank MacDonald, our chief scientist; and Tom Donahue, Chairman of the Space Science Board, is administered through a series of contracts grants that come mostly from headquarters in various scientific fields. We have not been able, at the present time, to do anything specifically for instrumentation at the universities and that's a program we're proposing to fund, along with other Government agencies, in fiscal 1985, in which we will make special grants to universities for instrumentation, test equipment, and so on.

Mr. VOLKMER. Well, we provided money in 1984. I just wondered what's going to happen to that money?

Dr. EDELSON. Well, that'll be used for research grants and support. I didn't realize that that was tied to specific instrumentation.

Mr. VOLKMER. That was the intent. At least I have to go back and look at the appropriations. But in the authorization it was specifically provided for instrumentation and about $7 million of the total.

Dr. EDELSON. I promise to get you a specific answer to that question.

Mr. VOLKMER. I'd appreciate that. We've had you long enough. I have more questions, if it's all right I'll submit some of them in writing. Requests that you answer those in writing. We'll hold the record open until you can do so. I have no additional questions. Thank you very much, Dr. Edelson.

Dr. EDELSON. Thank you, Mr. Chairman.

[Questions and answers submitted for the record follow:]

Responses to Written Questions from Chairman Volkmer from the July 28 hearing.

QUESTION E-1:

You describe a Titan Probe using some spare hardware "left over" from the Galileo program.

a. How would this new program interact with Galileo? That is, if you begin to modify the spare equipment for the Titan mission as you say would be necessary, it would no longer be a spare for Galileo. How would this work?

b. Science Magazine has reported that this mission might be done jointly with ESA. What would ESA and the U.S. each contribute?

ANSWER E-1:

a. For some time now, groups involved in planning the future of Planetary Exploration have talked of potential Titan Probe Missions. The SSEC ranked the Titan Probe Mission as fourth in its priority list after VRM, the Observer MGCO and the Mariner Mark II Comet mission. The SSEC considered two versions of the Titan mission. The first was a so called Mariner Mark II Mission which would derive its cost benefits from being the second in a series of missions, following, of course, the Comet mission. The second approach considered by the SSEC was a Galileo derived mission; that is, a spacecraft system development which depended heavily on Galileo heritage. The SSEC rejected the latter approach based primarily on the inefficiencies associated with the long trip time which is a consequence of the large mass associated with any combined orbiters and probe mission where the Saturn orbiter is as capable as the Galileo Spacecraft. The proposition considered, however, was one in which the Galileo project would have been expanded to include the Jupiter and Saturn systems as targets for exploration. Hardware currently considered spares on Galileo would have been used to build the second spacecraft. I must hasten to add, however, that the development cost on Galileo would have had to be increased substantially since:

1) Galileo does not currently have 100 percent of the spare hardware required to build a second orbiter.

2) The Probe system would have required modifications to the parachute system as well as new instrument accommodations;

3) New instruments would have had to be developed for the Titan science objectives, most notably a radar mapper for the orbiter and a gas chromatograph for the probe.

None of the modifications required would have preempted the use of the discussed spare hardware for the current Galileo mission objective ... the 1986 launch for a 1988 arrival at Jupiter.

b. Discussions are currently underway between European and American scientists brought together in a joint working group by the

National Academy of Sciences and the European Science Foundation. These discussions have included those reported in Science Magazine. Here again, the Joint Working Group is considering several options.

The options are the same as those considered by the SSEC with one exception, that is, the Galileo derivative mission would be a much later launch, 1990 - 1991 as opposed to 1987 which was considered by the SSEC. The report of the Joint Working Group is in its formulation stages and it would be inappropriate to prejudge their conclusions. It is clear, however, that if NASA and ESA were to develop this mission along the lines of Galileo, i.e., a combined carrier and probe, then two options for the distribution of responsibilities exist:

1) If the probe carrier is a flyby carrier or a lightweight simple orbiter then ESA would develop the carrier and NASA would develop the probe;

2) If the probe carrier is a broad, scientifically capable orbiter, then in order to maximize Galileo inheritance NASA would develop the orbiter and ESA would develop the probe.

With regard to other contributions, NASA would need to provide Radio-isotope Thermal Electric Generators (RTG's) in either scenario. Operations would be performed by ESA only in the case of the first scenario.

QUESTION E-2:

Because modernization of equipment and instruments in university research laboratories is important in maintaining a strong, innovative long-range research capability in the United States, NASA plans to upgrade university research instrumentation and equipment through the Space Research and Technology program. (P. VII-15 of the Program Plan)

a. What is the planned budget for this for FY 1984? For FY 1985 through 1988? How are you going to respond to Congressional action on this?

b. How will money be made available to universities?

c. What are criteria for awarding money for these programs?

ANSWER E-2:

a. NASA has not yet made a determination of the specific funding levels by fiscal year which will be provided to universities for research instrumentation. The Committees will be informed of NASA's plans as soon as they are finalized.

b. NASA is currently studying the best way in which to distribute this money to the universities while insuring that it is spent in a way which will be generally supportive of current and future NASA programs. NASA's Chief Scientist is cochairing with Dr.

Tom Donahue, Chairman of the Space Science Board, a committee to examine NASA university relations. The recommendations of this committee will be taken into account in designing the best means to make this money available.

c. The final criteria for awarding the money have as yet not been established. Key considerations will be the usefulness of the proposed equipment to current and future NASA programs, the quality of the permanent faculty at the institution, their degree of prospective participation in the NASA program, and the urgency of the need.

QUESTION E-3:

Some of NASA's own facilities and laboratories are in need of repair and rehabilitation and NASA has a 5-year facilities plan which includes the upgrading of facilities (p. 11-14). The university laboratories which have supported the NASA mission are in many cases also in need of repair and rehabilitation.

a. Does NASA have any plans for rehabilitating university facilities in the next five years?

ANSWER E-3:

a. NASA has as yet not formulated a specific plan for the rehabilitation of university facilities which offer strong promise of continuing support for the NASA program. This problem is being addressed along with the upgrading of university research instrumentation and equipment.

QUESTION E-4:

The promotion of international cooperative activities in the national interest is considered as one of the basic goals of U.S. space activities. A concern of some individual scientists in these cooperative efforts is that the U.S. provides the ride (vehicle, launch) and opens competition for instrument payloads to foreign scientists, in some cases, favoring foreign experiments in the spirit of "international cooperation." It is felt as a slight to American scientists who have meritorious proposals.

a. To what degree is NASA willing (or planning) to internationalize the OSSA program?

b. To what degree is NASA going to depend on international cooperation to keep the science programs afloat?

c. Is there a policy of reciprocity between NASA and ESA? As ESA scientists can compete for U.S. payloads, can U.S. scientists freely compete for ESA payloads? The policy is not clear.

ANSWER E-4:

a. NASA is willing to cooperate internationally whenever it is in the best interest of the United States and will enable first rate scientific research to be done.

b. NASA does not intend to become dependent upon international cooperation in order to conduct viable scientific programs. The best international cooperation comes from a sharing of our strengths with the strengths of others.

c. Historically, NASA has had the lead in virtually all areas of space activity involving science and, in accordance with national policy, foreign scientists have been permitted to propose to U.S. missions when they were able to obtain support from their governments. ESA has now matured to the point where there are interesting opportunities for U.S. science investigators on European missions. Although there is no reciprocal policy at this time, NASA and ESA officials are working to establish a reciprocal policy on participation in scientific missions. There is also the need to establish the mechanisms for funding U.S. participants in foreign missions since the amounts of money involved could be substantial and the final decision to accept a given proposal and proceed with a given mission would presumably rest with the nation organizing and providing the principal financial support. Mechanisms for cooperative missions have been established for some time and are functioning quite well.

QUESTION E-5:

The OSSA budget was to go up 25 percent in FY 1985 for ongoing and approved program budgets (run-outs) only.

a. How much will be added to that in FY 1985 to pay for Space Telescope cost overruns?

b. Will ST cost overruns threaten full funding of ongoing program budgets?

c. What are the prospects for FY 1985 new starts in light of Space Telescope cost overruns?

ANSWER E-5:

a. The Space Telescope project review has not yet been completed, therefore, a revised estimate of the Space Telescope requirements is not yet available.

b. Funding of the ongoing OSSA program is expected to be affected only marginally, if at all, by the Space Telescope overrun.

c. OSSA plans to present several new start flight missions for inclusion in the NASA budget. However, the NASA budget process involves review and consideration of non-OSSA candidate missions, and, therefore, total agency priorities are considered when deciding which OSSA new starts NASA will submit in its FY 1985 budget.

QUESTION E-6:

Space Station

a. How is this 5-year plan affected by the 5-year plan for Space Station?

b. Is there a policy to adequately fund space science and applications during the development of a space station?

ANSWER E-6:

a. The OSSA program outlined in the 5-year plan includes no Space Station funding for instrument development, science investigations, and instrument integration funding. Funds for such supporting activities are additive to the OSSA planning budgets.

b. The OSSA 5-year plan represents a healthy funding profile for OSSA, one which permits not only maintenance of OSSA strengths and capabilities, but also would allow for a planned expansion and growth in new scientific endeavors. There is no reason to assume that the OSSA program would not receive continued support from NASA management, OMB, and the Congress.

QUESTION E-7:

The Advanced Communications Technology Satellite (ACTS) program hopes to get partial industry support. Has this materialized? Have you gotten responses from industry?

ANSWER E-7:

Proposals from industry for the ACTS have been received and are currently in the fact-finding phase. Therefore, specific numbers on the amount of cost saving we will obtain through industry support are not available.

QUESTION E-8:

Your viewgraph shows that Headquarters spends $126.1 million. What do you do with that money, that is, what programs and institutions are supported?

ANSWER E-8:

The Headquarters funding for FY 1984 is estimated to be about $126 million. The four OSSA program areas--Life Sciences, Planetary, Physics and Astronomy, and Space Applications--manage and distribute these funds to the NASA research community, both to universities and to NASA field centers. A very small percentage of these funds is administered by Headquarters to cover R&D contract administration through the Defense Contract Auditing Agency.

QUESTION E-9:

In your testimony you stated that some priorities were set by a vote. Please explain this more fully. For example, who votes?

ANSWER E-9:

The use of the term "vote" was not intended to be taken in a literal sense. In May of this year, I convened a one and one-half day meeting with the OSSA senior managers to address a range of programmatic and planning issues and to assess future directions for our organization. Program planning was a major focus of our discussions. As we

proceeded it became clear that there was a strong concensus in the group that a major issue that needed to be addressed was the need to make some hard choices about future missions consistent with the likely availability of budgetary resources. It was felt that we should not continue to plan and fund definition studies for new flight projects that have no reasonable expectation of resulting in new flight opportunities within the next five to ten years. There was also a widely-shared feeling that there was a need to clearly delineate mission priorities, in order to minimize misunderstanding and disruption in the scientific community.

As a result of these concerns, my division directors, advisors, and I debated the relative priorities of the various science and application missions currently under consideration for initiation in the next five years. The consensus that emerged as a result of our discussions led to the development of the mission planning chart presented in my July 28 testimony. I have presented this material to the Space Science Board, the Space and Earth Science Advisory Committee, and the NASA Advisory Council. I expect it to serve as the basis for intensive discussion with the scientific community as we refine our program planning during the next year.

QUESTION E-10:

Does the Geopotential Research Mission (GRM) have military implications?

ANSWER E-10:

The GRM will provide accurate global models of the Earth's gravity and magnetic field. The military has an interest in both types of field models.

DOD has acquired from NASA and used the magnetic field model produced from Magsat data and has expressed a desire to use the updated magnetic field model that will be obtained from the GRM. These updates are needed because the Earth's magnetic field changes by about 1 percent per year in an unpredictable manner. This requires frequent revisions to magnetic field charts that are used for navigational purposes. Up-to-date magnetic field models are also needed for the removal of the Earth's main field for detailed studies of local magnetic signals.

For accurate missile guidance it is our understanding that current guidance technology is such that improved gravity field models would not significantly effect targeting errors. However, GRM gravity information could be significant if future technology advancements succeed in reducing other tracking errors.

The improvement in the gravimetric geoid (the surface corresponding to mean sea level) that would be realized from GRM would be useful in studies of ocean circulation (and possibly weather prediction) and consequently would be useful for military ocean operations.

QUESTION E-11:

Your viewgraphs showed Gravity Probe-B (GPB) as a potential new start. Is this the first time it has been listed as a new start? Has it

slipped? Stanford University has played a major role in both the science and the development of new technology for this mission. What role would they play if the project is a new start?

ANSWER E-11:

Gravity Probe-B has been of interest to NASA as a candidate science mission for a number of years. Stanford University and the Marshall Space Flight Center have developed several challenging technologies that enable the consideration of a GP-B Mission. However, it has been only during the last three years that the component technologies for the mission have been demonstrated individually. The task for the next few years is to demonstrate the successful integration of these technologies into a system capable of performing the GP-B Mission. In this regard, the new start time for the GP-B Mission will be determined primarily by technology development and readiness. The technology is now to the state where mission planning can occur with increased understanding of technological and programmatic risks. In this context, GP-B is not a new mission.

QUESTION E-12:

In your testimony you stated that our requested study of Sun-Earth Interaction referred to a subject area that is equivalent to what is usually called Solar-Terrestrial Physics. A careful reading of our language will show that we requested a much broader study, and indeed that is why we used a different name for it. You also said that several National Academy of Sciences studies had already been done on the subject. Yet a letter from the Chairman of the NAS Committee on Solar and Space Physics to the President of the Academy expresses enthusiasm for the requested study and stated that it would "expand upon previous studies in this research area." How do you plan to respond to our request?

ANSWER E-12:

The National Academy has initiated a review of an International Geosphere Biosphere Program (IGBP) which we believe encompasses the topics included in your requested study of Sun-Earth Interaction. We understand that it is not just the interaction which is of concern to the Committee, but the science involved in the study of everything from the center of the Sun to the center of the Earth. It is our intention to support the IGBP activity at the Academy as one means of responding to your request. In view of this related activity, we intend to participate and capitalize on this opportunity to address the concerns of the Committee in the broader context.

In addition, we at NASA are forming an Earth System Science Committee which will play a role in this area similar to that which the Solar System Exploration Committee has played in the planetary area. We will also continue to support the activities of the Committee on Earth Science and the Committee on Solar and Space Physics at the National Academy of Sciences, the Ocean Science Board, the Board on Atmospheric Sciences and Climate, the Geophysics Research Board, the Committee on Geodesy, the Space Science Board, and other relevant elements of the National Academy of Sciences.

QUESTION E-13:

What is your long-range plan for better analyzing and using the data resulting from your program?

ANSWER E-13:

The National Academy's CODMAC (Committee on Data Management and Computation) has been studying this particular question and is making recommendations that may provide the basis for improved planning in this area. Data use is a key concern in all of our proposals for future missions.

QUESTION E-14:

What is your plan for the Solar Orbiting Telescope (SOT)?

ANSWER E-14:

The SOT program is currently in an extended definition phase. In the near future we will be redefining the SOT schedule and cost estimate.

QUESTION E-15:

What is being done in the Solar Maximum Mission to see that the guest investigator program gets adequate and timely funding support?

ANSWER E-15:

We are currently in the process of defining a guest investigator program for the Solar Maximum Mission and the funding that will be required to support this program.

27-459 O—83——8

Material requested for the record on page 33, lines 610 - 813 from Mr. Brown.

The Space Science and Applications 5-year plan assumes a runout for potential FY 1985 and subsequent new starts for FY 1986 - FY 1988. This is based on internal planning and is, of course, dependent on many factors. Elements included in these planning projections are as follows:

FY 1985: Planetary Exploration
- o Mars Geochemical/Climatology Mission

Space Applications
- o Upper Atmosphere Research Satellite Mission
- o Ocean Topography Experiment

FY 1986: Planetary Exploration
- o Comet Rendezvous Mission

FY 1987: Physics and Astronomy
- o Advanced X-Ray Astronomy Facility
- o X-Ray Timing Explorer

Space Applications
- o Origin of Plasma in Earth's Neighborhood
- o Geopotential Research Mission
- o Solar Dynamics Observatory

FY 1988: Physics and Astronomy
- o Gravity Probe-B

Material requested for the record on page 61, lines 1497-1498, by Chairman Volkmer.

NASA has not yet made a determination of the specific funding level in FY 1984 which will be provided to universities for research instrumentation. However, the Committee will be informed of NASA's plans regarding this matter as soon as our plans are finalized.

Additional material for the record, page 45, lines 1107-1110, during the August 11, 1983, hearing.

The possible use of the Ariane launch vehicle would simplify putting TOPEX into its orbit, which requires a 65-degree inclination and 1300-km altitude. This is not a "standard" Shuttle orbit; there is currently no other identified payload which requires this inclination, so the TOPEX launch might have to be a dedicated launch. Therefore, since the Ariane launch vehicle can insert TOPEX directly into the proper inclination and altitude, no additional booster capability would be required to get the spacecraft to the required altitude. It is possible then that the French involvement would save NASA the cost of a dedicated Shuttle launch; these savings could be significant, and this is the reason we are considering a cooperative TOPEX venture with the French.

Mr. VOLKMER. Our next witness is Mr. Robert E. Smylie, Associate Administrator of the Office of Space Tracking and Data Systems.

STATEMENT OF ROBERT E. SMYLIE, ASSOCIATE ADMINISTRATOR OF THE OFFICE OF SPACE TRACKING AND DATA SYSTEMS

Mr. SMYLIE. Thank you, Mr. Chairman. I will also speak from viewgraphs. First, I appreciate the kind words at the beginning of your statement concerning our efforts to place the tracking and data relay satellite in the proper orbit after the problem we had in the STS–6 launch of the upper stage failing shortly before its burnout and placing it in an orbit that was 8,600 miles low at perigee. I thought the chairman might be interested in the small orbit-adjust engine that we use to adjust that orbit. We have one of them here. You can let me have it for just a second.

This is the thruster on the—that is used to provide 1 pound of thrust normally for attitude control and for station keeping, a catalyst bed, a small tube, and a valve and a fuel line, the hydrazine line, hooks on here. That's the actual size, in fact, one of the type of engines that's used on the tracking of a relay satellite.

Mr. VOLKMER. How many thrusters are there on it?

Mr. SMYLIE. There are 24 of those engines, thrusters, on the satellite; it's a redundant set. Twelve in one system and 12 in the other. They're used for station keeping, for attitude control and for unloading the momentum wheels occasionally throughout the mission. For the purposes of orbit adjustment we use only one of those engines. We use five for controlling the stability of the spacecraft and one to provide the velocity change to allow us to get to the proper orbit. It took 39 maneuvers using one of those engines for a period of about 45 hours of burn to accomplish that orbit adjustment. We're very pleased and relieved that we were able to do that. The spacecraft is now in checkout. We are proceeding reasonably well; we do have our problems from time to time; more than we would like to have, but we do have a brand new system. The operators are new. With the satellite, many of them are skilled and have done this kind of work throughout their career. But this is a brand new satellite, they've never operated before. There's a great of software; an automated, sophisticated system; and a great deal of hardware, and a lot of procedures.

The schedule for accomplishing that checkout is behind where we would like to be, but not much behind where we thought we might be. You recall at the time that we started this mission, we were counting on and planning on 5 months of checkout, before launching the second satellite and another 2 months before launching spacelab and that's been shortened to 3 months. So we're trying to accomplish in 3 months what we originally planned to do over a period of about 7 months.

Mr. VOLKMER. Can I ask you a question before you go on. In regard to the checkout, are all the instruments on the TDRSS working? The problem that we're having is a matter of basically operations between here and there. Is that it?

Mr. SMYLIE. Yes, sir. Well, operations primarily at the White Sands Ground Station which is where the activity goes on. But so

far we're still checking things. But so far, the things that we have checked on the satellite are all working. We have no significant problem with anything on the satellite. I know of no problem at this time on the satellite itself. I'm with communications payloads. I'll qualify that, because we did have one of these thrusters fail shortly into the mission, about 6 hours into the mission. So we did have that failure that has disabled half our attitude control system. But that's not a significant problem at this time.

Long Range Plan Summary Presentation

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

JULY 28, 1983

PRESENTED BY
R. E. SMYLIE

National Aeronautics and Space Administration
Twenty-fifth Anniversary
1958-1983

MAJOR PROGRAM OBJECTIVES

- PROVIDE TRACKING AND DATA SUPPORT OF ONGOING AND APPROVED MISSIONS
- BRING THE TDRSS SPACE NETWORK ON LINE
- DEVELOP USES FOR CAPABILITY GAINED THRU TDRSS CONTRACT RESTRUCTURING
- CONSOLIDATE STDN & DSN INTO A SINGLE GROUND NETWORK TO SUPPORT HIGH EARTH ORBITAL, GEOSTATIONARY AND DEEP SPACE MISSIONS
- SUPPORT THE VOYAGER URANUS AND NEPTUNE ENCOUNTERS
- COMBINE NASA "PROGRAM SUPPORT COMMUNICATIONS" INTO A SINGLE EFFICIENT NETWORK
- SUPPORT SPACELAB DATA PROCESSING AND SPACE TELESCOPE MISSION CONTROL
- BEGIN PLANNING FOR FUTURE BEYOND TDRSS AND PROVIDE TECHNOLOGY DEVELOPMENTS TO FACILITATE USE OF THE TDRSS SPACE NETWORK

NASA HQ TE3-3448 (1)
6-30-83

2

I will speak with viewgraphs (figure 1). In the interest of time, I will go through them fairly rapidly. Stop me if I go too fast. Of course, I'll respond to questions at any time. May I have the first viewgraph (figure 2). I also work with a set of program objectives that are listed here. My function is to provide support and service to the rest of the NASA program so both space and aeronautics so out put is my primary objective, or right at the top of my chart is to provide that tracking and data support to the ongoing and approved missions of the Agency. In terms of my long-range planning, it does get very much intertwined with what is being planned by the other program offices of the Agency. Because I must look ahead and examine what the rest of the program offices are planning to do and assure that the capability that I put in place, or have in place is sufficient to provide that tracking and data support to those upcoming missions. The tracking and data relay satellite is such a key element in our ability to provide that support to the upcoming missions and the approved missions, it's absolutely necessary for space telescope, for many shuttle missions, to some degree for spacelab and other programs that Dr. Edelson talked about. We must have as very high priority in our planning to bring that system into an operational state.

As you are aware, we modified and restructured the TDRSS contract last December and in the process of doing that, the tracking, I mean the commercial capability hardware that is on those satellites became available for Government use if we could devise, within the bounds of regulation, legislation and capability to utilize that. I think we should find ways to use that to advantage, either for NASA, or the Government, or other purposes and we plan to do that. We're in the process, and we put it to the committee for the last several years that, as a result of bringing the tracking and

relay space network on line, we had the opportunity to do certain consolidations for efficiency and management purposes within the remaining ground network and the DSN. I consider that to be a high priority activity to make our operation more efficient, more cost effective, and also at the same time, more capable.

We currently have a spacecraft that has gone past Jupiter and Saturn, is on its Uranus and then on to Neptune. I have as high priority to make those modifications necessary in the network to get the adequate return from those missions when they reach Uranus and Neptune. We have a communications network that serves the nonoperational portions of the Agency that have grown up as a number of unique and individual services. I'm in the process, through my office, of combining that into a network that we believe will also be more efficient and more cost effective.

We are in the process of implementing a spacelab data processing system, in fact, it is practically finished now and the space telescope mission control system at Goddard which is in the process of development. Since those are also high-priority missions, we put that as a major objective. And then just planning for the future, beyond TDRSS and for the upgrades of the DSN necessary to support future missions. I'll speak to each of those objectives in some more detail now, could you put the next chart up (figure 3), please?

SPACE NETWORK PLANNING
• GET TDRS-1 OPERATIONAL AT 41° WEST.
• ESTABLISH FINAL PLANS FOR LAUNCH OF TDRS-B AND -C BASED ON RESULTS OF IUS INVESTIGATION.
• DEVELOP EARLY USER SUPPORT CAPABILITY.
• COMPLETE FULL OPERATIONAL CAPABILITY OF GROUND SYSTEM ELEMENTS
• NETWORK CONTROL CENTER
• WHITE SANDS GROUND TERMINAL
• SECURITY UPGRADES
• IMPLEMENT GOVERNMENT USE OF C-BAND CAPABILITY
3

Our plans on the tracking and data relay satellite is to continue our checkout. We have greatly compressed and streamlined that test operation to do those things, peculiar to the support of the spacelab mission on STS–9. We are concentrating on that part of the test program until we get that mission behind us. As part of that, we would consider it highly desirable to interact the TDRSS with STS–8 during the STS–8 mission. So we're further vectoring

that test program; we do those things to maximize our chances and our ability to utilize TDRSS in a test mode during the STS–8 mission. We're currently at 64 degrees west rather than the required 41 degrees and we'll do most of our checkout in support of STS–8 at that location and immediately after that mission, we'll drift the spacecraft over to 41 degrees which is where we have to be for spacelab. Their timeline, the spacelab timeline, is tied to that location for the tracking and data relay satellite. It will take us about 30 days to do that drift, but we'll continue checkout during the period of that drift.

SPACE NETWORK PLANNING

- SUPPORT TO USERS
  - SPACELAB
    - PLAN TO SUPPORT WITH ONE SPACECRAFT IN EAST POSITION
  - LANDSAT
    - EARLY SUPPORT DURING CHECKOUT OF TDRS-1
    - OPERATIONAL SUPPORT AFTER SPACELAB
  - STS
    - EARLY SUPPORT AND TESTING UNTIL AFTER TDRS-B ON ORBIT
  - OTHER USER SUPPORT
    - SME - ON ORBIT
    - SMM - AFTER REFURBISHMENT
    - SPACE TELESCOPE
    - STS ATTACHED PAYLOADS

NASA HQ TCSS-3025 (1)
5-17-83

4

Our plans for the future launches of the future spacecraft are tied to the results and the resolution of the problem that we had with the inertial upper stage on the STS–6 mission (figure 4). We are manifested for March of next year for the B-launch and, I believe, September of next year for the C-launch. It is somewhat questionable as to whether the IUS will have reached a state of resolution of its problems to hold that schedule. So we're looking at contingencies as late as next November for the launch of the second satellite. But, we believe that the truth is somewhere in between March and November of next year for resolution and launch of the second satellite. We would put as an objective, and I really ought to have talked about this early user support already by saying I'm working with STS–8 and spacelab. Another high priority for us in the process of checking out that first satellite is also to provide support to Landsat-D which currently is having a power problem. It may have to be brought from its operational orbit to a lower orbit at most any time. So we would like to get into a posture

to get some data from Landsat-D as early as possible. We currently have 2 days of testing planned before STS–8. We may have to give that up and move it to after STS–8. But we do consider that high priority.

To develop the full operational capability of the ground system elements, so far we are primarily exercising the White Sands ground terminal in its current configuration. The network control center at Goddard is not too much involved at this point because we are not scheduling spacecraft support which is the primary purpose of that center. On security upgrades that have to do with the physical security and the communications security of the activities at White Sands and that will become fully operational in the 1985 timeframe.

TDRSS C-BAND CAPABILITY

- PLANS FOR USE OF C-BAND CAPABILITY
  - TDRSS EXPECTED TO HAVE SIGNIFICANT ROLE IN PROVIDING NASA DOMESTIC COMMUNICATIONS NEEDS
  - DISCUSSIONS NOW UNDERWAY ON USE OF C-BAND PACKAGE BY OTHER GOVERNMENT AGENCIES
    - NOT TO INTERFERE WITH TDRSS MISSION
    - NASA WOULD CONTROL TRANSPONDERS
    - GROUND SYSTEMS WOULD BE RESPONSIBILITY OF USER
  - NASA IS INVESTIGATING MODIFICATIONS OF TDRS-C AND SUBSEQUENT SPACECRAFT TO OPTIMIZE COVERAGE

NASA HQ TC83-2693 (1)
5-17-83

5

I have already talked about, somewhat the Government use of C-band capability. The next chart (figure 5), I think I've really talked about, except that the other user support includes the solar mesopheric explorer which is currently in orbit. That's a small spacecraft control from the University of Colorado. It is configured to utilize the tracking and data relay satellite and as soon as we're able to we would begin to support it with that satellite. The solar max mission is a spacecraft, is a tracking and data relay satellite compatible spacecraft. It currently could not operate with TDRSS because of its instability. But after it's refurbished from the repair mission next year, we would expect to utilize for SMM and of course for the space telescope and the attached payloads of the shuttle.

The C-Band capability which is commercial package on the Tracking and Data Relay Satellite we believe can have a signifi-

cant role in providing service to NASA and to other Government agencies, primarily the USIA and the DOD and possibly others. We have discussions underway between our agencies now as to how we might proceed to do that and we might make some modifications to that C-Band coverage to optimize it for government use on the later spacecraft, possibly B, C, and D, depending on their launch schedule.

GROUND NETWORK SYSTEMS OVERALL PLANNING

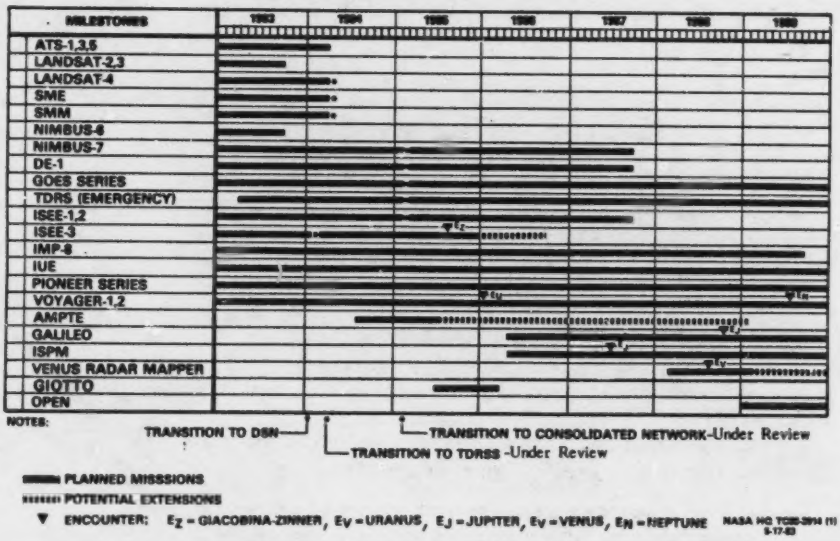
- SUPPORT TO HIGH PRIORITY ON-GOING MISSIONS
- CONSOLIDATE GROUND NETWORK
  - COLOCATE GSTDN STATIONS AT THREE DSN COMPLEXES
  - RECONFIGURE LAUNCH/LANDING STATIONS FOR GREATER EFFICIENCY AND RELIABILITY
  - CLOSURE AND DISPOSITION OF REMAINING GSTDN STATIONS
  - ENSURE CONTINUITY OF USER SUPPORT
- COMPLETE PREPARATIONS FOR URANUS ENCOUNTER, BEGIN PREPARATIONS FOR NEPTUNE ENCOUNTER
- MODIFY DSN TO SUPPORT THE ISEE-COMET MISSION
- INCREASE SUPPORT CAPACITY OF DRYDEN FLIGHT RESEARCH CENTER RANGE

NASA HQ TCDS-3PW (1) 9-17-80 6

In the ground network (figure 6) that will remain after the Tracking and Data Relay Satellite is operational, I've already talked about the fact that we plan to consolidate and, in fact, that is well underway and will be completed by early 1985. We will colocate an antenna at each of the DSN stations in Australia, Goldstone, and Madrid with the DSN antennas and then put the management of that remaining network under JPL. And that in fact means the management of one antenna moves from Goddard to JPL and becomes part of the complex at the DSN and will be utilized to support those remaining Earth-orbital missions that are not compatible with the Tracking Data Relay Satellite.

We plan to complete our preparations for the Uranus and Neptune encounter, modify. And this is a small modification of the DSN for the ISEEcomet mission, and increase the support capacity which is really an aeronautics program of the Dryden Flight-Research Center range. We can currently handle one mission at a time there. And, with some modest duplication of equipment, we can handle dual missions, either in preparation for more than one while the other is flying or actually flying two, at the same time, aeronautics program.

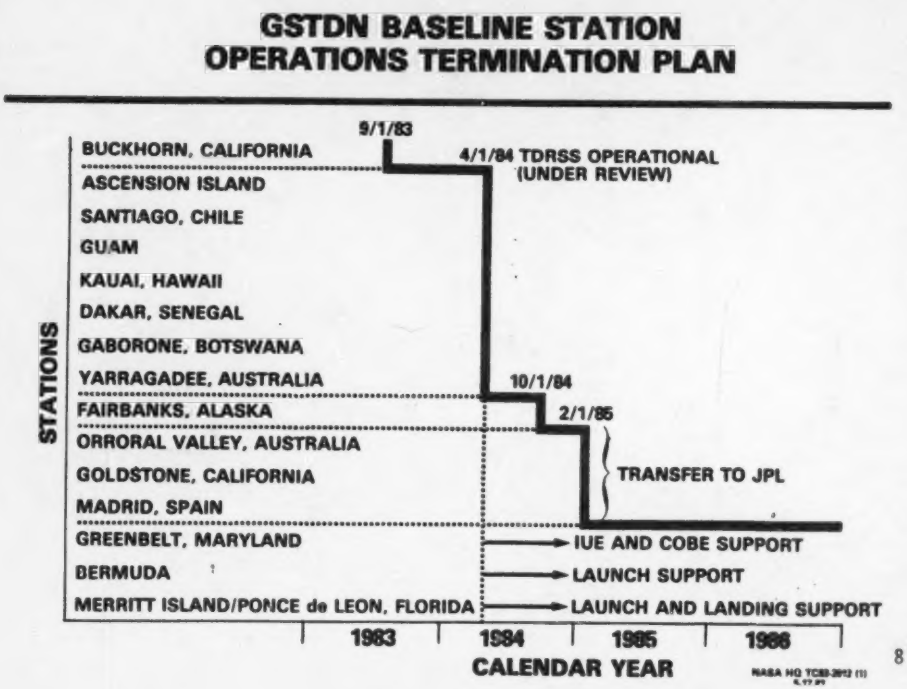
MAJOR GROUND NETWORK MISSION SUPPORT



7

This next chart (figure 7) shows major ground network mission support systems, soon to be at the end of their useful life. The same with Nimbus 6. Nimbus 7 is a primary one and will continue to be supported by the remaining three stations that are combined with the DSN and DE-1 is another one. The GOES and TDRSS are for emergency primarily or for station changes for GOES. The rest of those I think I will not mention unless there are questions about them.

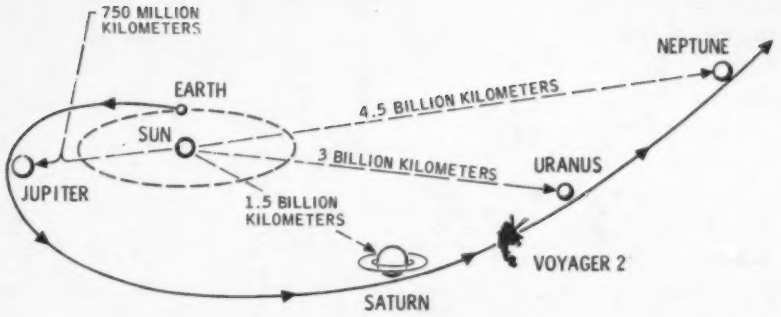
Giotto is DSN support to the Halley Comet Mission of ESA, and that's a reimbursable mission.



The next chart (figure 8) talks about how plans for station closure, and that is under review. Just take that other chart down and put it over on the other—that'll be fine. This was our plan for station closure. Our planning called for closing a number of stations in April of 1984. We will not be able to do that because we will not have the Tracking and Data Relay Satellite System operational by that time; so we must extend those stations for some period of time. We have already announced an extension to about September, through the end of the fiscal year, and we will review that decision as the IUS situation develops. The rest of that remains as shown.

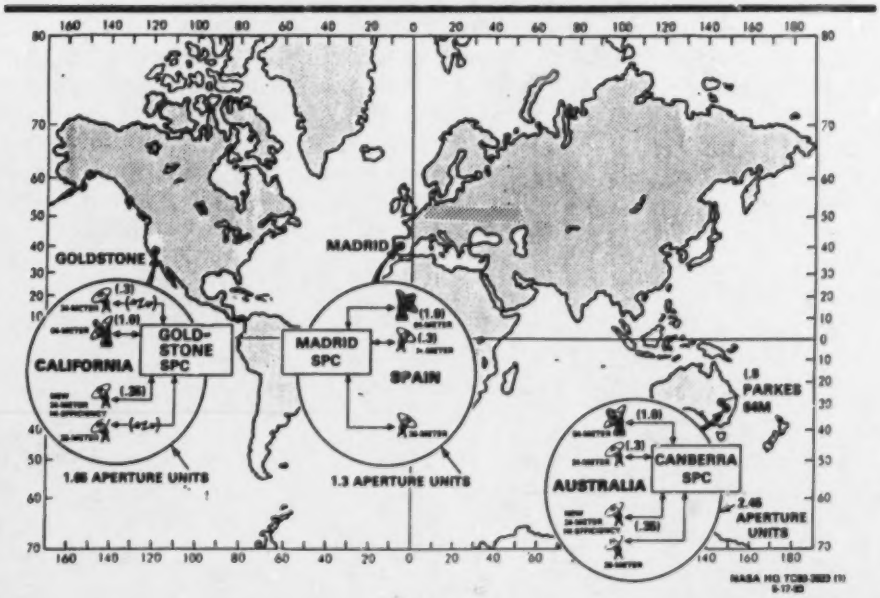
INTERPLANETARY MISSION

VOYAGER 2



8A

1985 CONSOLIDATED NETWORK/URANUS SUPPORT CONFIGURATION



9

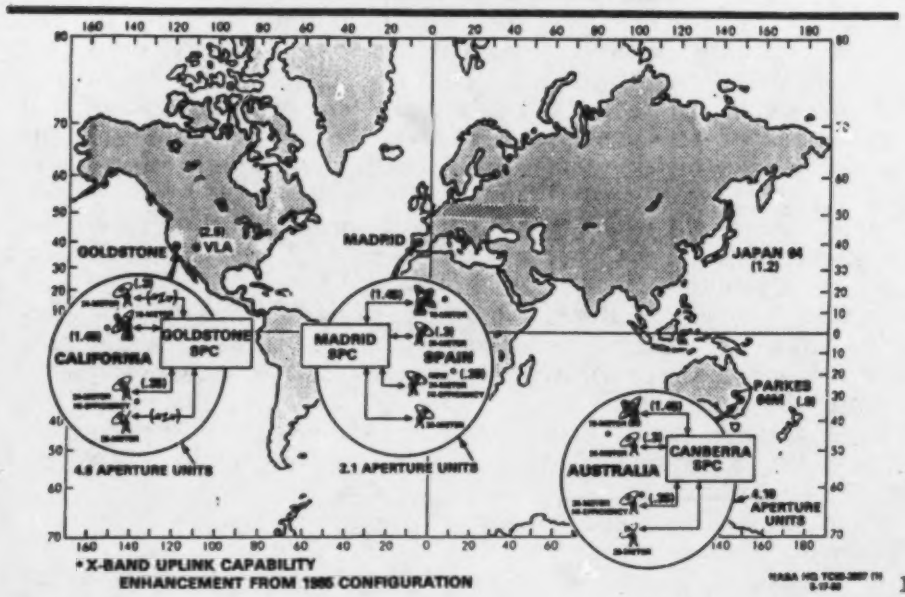
The next chart (figure 8A) talks in some detail about what we are doing in the DSN to support the larger mission at Uranus. We've taken as a standard of comparison (figure 9) the sensitivity or the capability of one of the existing 64-meter antennas, and we

call that a unit of one aperture. By the things that we are doing at Goldstone, the total capability of that network or that station will be equivalent to about 1.65, 64-meter antennas. We're doing that by arraying the currently existing 34-meter antennas at Goldstone with the 64-meter, and we've already done that for the Voyager-Saturn mission. We currently have under construction, as approved in previous budgets, a new 34-meter, high-efficiency antenna that is currently under construction at Goldstone; the combination of those three will give us that capability for the Uranus encounter.

In Spain, we are not adding for the Uranus encounter another 34-meter antenna, so we just have the two antennas currently there for that. It gives us the 1.3 units. In Australia, which is the prime station for the Uranus support, we are doing the same thing that we are doing at Goldstone, arraying the existing 34 and the existing 64 and constructing a new 34 to add to that array. In addition to that, or through a micro-wave length from the parts radio-astronomy antenna near Sydney, we are utilizing that 64-meter radio-astronomy antenna, which is a little less efficient than the NASA antenna. Still it adds a considerable capability, raising that capability to about 2½ 64-meter antennas equivalent. That is a cooperative program between ourselves, ESA, and the Australians because ESA will also use that Parkes antenna to support the Giotto mission. We will back them up from the Canberra complex on that Giotto mission. In return, we utilize that capability for our Uranus encounter of Voyager.

The next slide, and just about everything on that chart, in fact I believe everything on that chart, is part of the approved program for the Uranus encounter and we're proceeding with that.

1989 VOYAGER/NEPTUNE & GALILEO SUPPORT CONFIGURATION



* X-BAND UPLINK CAPABILITY ENHANCEMENT FROM 1985 CONFIGURATION

10

The next chart (figure 10) talks about what we are planning to do, subject to administration and congressional approval, for the Neptune encounter. The reason we're doing most of this or all of this, in fact, is that the Voyager spacecraft is on its way to these distant planets; there's no change we can make in the spacecraft capability, but the distance, the amount of signal received at Earth from that satellite decreases as the distance from Earth increases; it decreases as the square of that distance. As an example, Uranus—the spacecraft will be twice as far from Earth as it was at Saturn. So we'll have only one-fourth the capability unless we do something to upgrade the network. By the time we get to Neptune, we've lost another fifty percent in distance, and twice that in the network, so we keep the science return from the mission fairly, try to keep it fairly constant. This slide shows the 3 to 4½ billion is about, well, it's 4½ over 3 squared is what we will lose. So for the support at Neptune at Goldstone, we still have the same complex at Uranus, the two 34's and the 64, but we are proposing and are negotiating with the operators of the very large array at Secorro, N. Mex., to utilize, through an array back to Goldstone, about half of the antennas that they have in that location. That is a radio-astronomy complex that's been in operation for 3 or 4 years now and it is comprised of 27 26-meter antennas arranged on three spokes, 120 degrees apart, and you can arrange those antennas in various configurations for radio-astronomy purposes. And for this particularly unique purpose of supporting Voyager at Neptune, we will have to add some particularly sensitive front ends to some of those antennas cyrogenically cooled and array them together and then electronically combine that signal from those at the Goldstone complex. If we're able to do that, we get about 4½ aperture units at Goldstone.

In Spain, we would propose to add another 34-meter antenna similar to what we've done in California and Australia for the Uranus encounter. That is primarily to get the sensitivity up such that we can get the science and engineering from the Madrid station. We would not get very much in the way of imaging with that much upgrade. But we need a continuity, as the Earth turns, of the science and engineering. We need that other antenna to be able to do that.

In Australia, we would continue with the Parkes array we are investigating the possibility of combining with the signal from a Japanese 64-meter antenna that they are building for their Halley's Comet mission, which will be complete in time for the Halley's Comet mission and could potentially be utilized, although we have not entered into serious discussions with the Japanese yet in utilizing their antenna.

Mr. VOLKMER. Before you go to the next view-graph, I got a vote on, and I'm going to have to run a vote. Actually, we will recess now for 10 minutes.

Mr. SMYLIE. OK. Thank you sir.

[Recess.]

Mr. VOLKMER. The order will proceed. Mr. Smylie may continue with your presentation.

AERONAUTICS, BALLOON & SOUNDING ROCKET SUPPORT

- ACTIVITIES AT:
  - WALLOPS
  - DRYDEN
  - MOFFETT FIELD
  - CROWS LANDING
  - PALESTINE, TX
  - WHITE SANDS
  - FOREIGN TEST RANGES WITH MOBILE T&DA SYSTEMS
- PROGRAM PLANS
  - MULTIPLE MISSION CAPABILITY FOR DRYDEN
    - TELEMETRY SYSTEM
    - RADAR TRACKING SYSTEM
    - REAL-TIME DATA ANALYSIS CAPABILITY
  - CONSOLIDATE DRYDEN, MOFFETT FIELD & CROWS LANDING FACILITIES UNDER DRYDEN MANAGEMENT
  - AUGMENT & IMPROVE WALLOPS T&DA CAPABILITY
    - IMPACT PREDICTION SYSTEM
    - REFURBISH FIXED RADARS

NASA HQ TE3-2442 (1) 9-30-82 11

Mr. SMYLIE. Thank you sir. I believe I was up to a chart entitled, "Aeronautics Balloons and Sounding Rocket Support." (figure 11) This is a small but critically important function of our organization to provide the tracking range for the aeronautics program at the Dryden, and the Ames Research Center, and at the Wallops Facility of the Goddard Space Flight Center. Also, the White Sands on that chart refers to the missile range where we launch sounding rockets. The National Balloon facility at Palestine, Tex., which we have assumed the responsibility for tracking activity there. Crows Landing is a Navy field near the Ames Research Center, maintained and operated by the Navy. We have a small tracking facility for support of NASA programs. That pretty well is an ongoing and well-constituted capability at all those places. The primary things that we are doing is at the Dryden Flight Research Center for several years we have been incrementally modernizing the capability there and bringing on-line a dual mission capability so that we can handle two missions at a time, either one in checkout and one flying, or two flying or two in checkout. This will greatly increase the productivity of the people and the range there at Dryden. In addition, we have brought, under single management, the tracking activities at Dryden, Ames, and Crows Landing such that the size of our aeronautical test range is greatly expanded and with a very effective cost way of doing it.

At the Wallops, it's primarily an upgrade of the impact prediction system for the sounding rocket program. That's really a computer. Refurbish the fixed radars that are some 20-something years old there. Both are fairly small programs.

OFFICE OF SPACE TRACKING AND DATA SYSTEMS
COMMUNICATIONS AND DATA SYSTEMS

- UPGRADE NASCOM CAPABILITIES FOR FUTURE DATA RATE NEED
- IMPLEMENT AN IMPROVED AND EFFICIENT PROGRAM SUPPORT COMMUNICATIONS NETWORK FOR NASA
- INCREASE PARTICIPATION AND INFLUENCE IN GLOBAL SPECTRUM MANAGEMENT ACTIVITIES
- DEVELOP NEW MISSION CONTROL SYSTEMS
- MODERNIZE COMPUTER SYSTEMS

NASA HQ TC83-2793 (1) 7-14-83 12

Our communications and data systems (figure 12), we are just having to track or follow the state-of-the-art in which we are rapidly moving from an analog world to a digital world. And, we are upgrading and changing our capabilities to follow that trend to allow us to handle the high-data rates that are necessary for the upcoming missions, including Landsat and spacelab.

NASA TELECOMMUNICATIONS
NASCOM

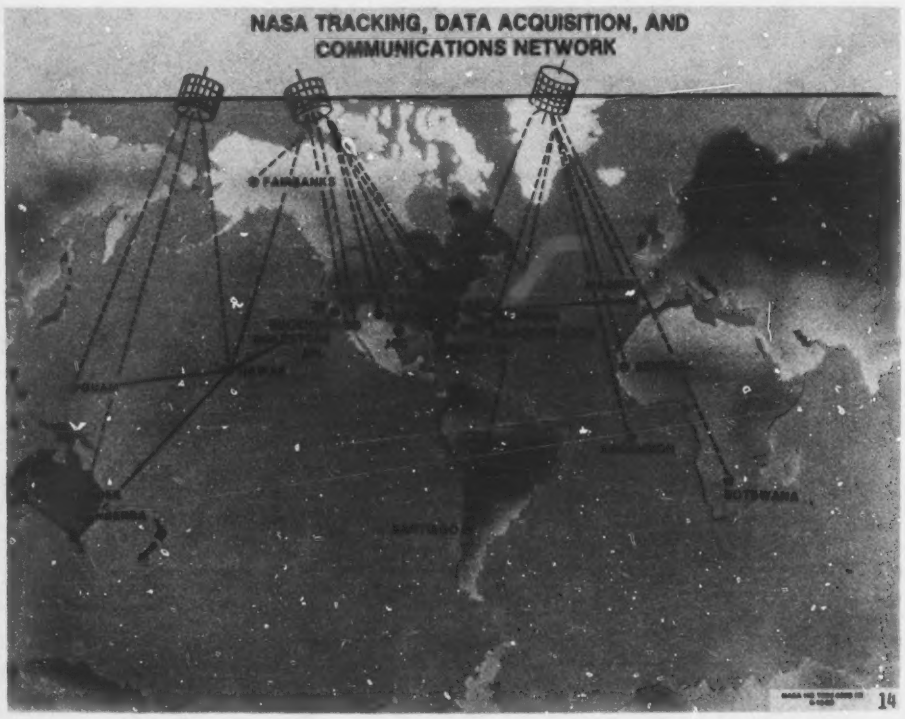
NASCOM - WHAT IT IS NOW

- OVER 2½ MILLION CIRCUIT MILES - DOMESTIC AND FOREIGN BOTH SATELLITE AND TERRESTRIAL
- 630 CIRCUITS TO 139 STATIONS
  - VOICE, DATA, VIDEO
  - ANALOG, DIGITAL
  - NARROW BAND, WIDE BAND
- 21 COLLOCATED DOMSAT STATIONS AT 11 NASA SITES
- BROADCAST MODE VIDEO SYSTEM TO ALL NASA CENTERS
- CONTROL CENTER - GSFC
- MAJOR SWITCHES AT CANBERRA, MADRID, AND JPL
- NEARLY ALL LEASED

NASA HQ TCSD-3488 (1)
6-23-82

13

NASA TRACKING, DATA ACQUISITION, AND COMMUNICATIONS NETWORK



14

The next slides (figures 13 and 14) talks about NASCOM. For the next few slides, we'll talk about what we have today and where we think we're headed over the next several years because it's something that is done incrementally year by year as the technology allows and as the requirements develop. NASCOM is our NASA communications network that handles our operational communications worldwide. It is a totally, almost totally leased system. It's managed by the Goddard Space Flight Center. It's comprised of many circuits, over 600 at a 139 locations around the world and handles both voice data, video, both analog and digital, both narrow and wide band. We utilize Domsats, Domestic Satellites primarily RCA, but some Amsat and Intelsat, for that communication purposes, plus submarine cables and landmines and micro-wave lengths in the United States.

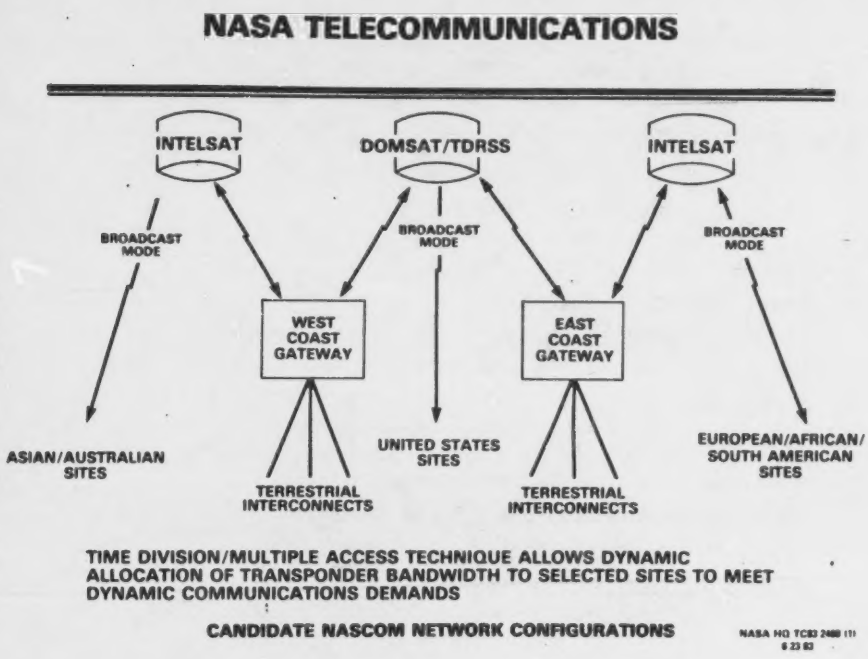
We have the capability for video to all NASA centers. You've seen that used for the shuttle program to bring shuttle video from Hawaii or other ground stations into the NASA centers and also delivering it to the commercial broadcasting systems. We have major switches in three locations: Madrid, JPL, Canberra, in addition to the control center at Goddard. As I've said it's nearly all leased.

NASA TELECOMMUNICATIONS

NASCOM - WHAT IT MAY BECOME

- A COMPLEX COMMON USER NETWORK COMPRISED OF WIDEBAND DIGITAL LINKS
- THESE LINKS WILL:
  - PROVIDE ACCOMMODATION FOR TDRSS BASELINE (4-10 MBS) TDRSS WIDEBAND (50 MBS)
  - UTILIZE TDMA TECHNIQUES FOR DEMAND ASSIGNED VOICE. HIGH SPEED DATA AND VIDEO
  - UTILIZE FIBER OPTICS FOR WIDEBAND INTERFACES AND LOCAL DISTRIBUTION
- CAN EXPECT LONG TERM STABILIZATION OF OPERATIONS COST
  - IMPROVED TECHNOLOGY
  - COMPETITIVE MARKET PLACE

NASA HQ TCSD-3447 (1)
6-23-89



16

Next slides (figures 15 and 16) show us where we're headed over the next several years. We would expect to go to primarily wide band digital links that will be time-division multiplexed and will reduce the need for as many circuits as we now carry, because we can then just multiplex data and voice into that link or into that system and we will likely use more and more fiber optics for the wide band distribution for local locations, not necessarily for long distances. The cost of this kind of communications is likely to stabilize, possibly even to come down, because of improved technology and much more competition in the marketplace for this kind of communication. These are the kinds of things that the long-distance private companies are providing, particularly with the divestiture and deregulation of the current communication system in the country. AT&T, of course, will be a strong provider and competitor in this area, but so also is RCA, Western Union, and any of the companies that are in the business of putting up domestic satellites and also producing micro-wave and fiber-optic landlines around the United States.

NASA TELECOMMUNICATIONS
PROGRAM SUPPORT COMMUNICATIONS

PSC - WHAT IT IS NOW

- 345,000 CIRCUIT MILES - BOTH SATELLITE AND TERRESTRIAL
- 75 VOICE TELECONFERENCE ROOMS
  - 4600 VOICE TELECONFERENCES IN FY 83
- 134 HI SPEED FAX STATIONS
- 149 LO SPEED FAX STATIONS
- PACKET SWITCHED NETWORK AT 11 LOCATIONS
  - DATA FOR SHUTTLE, LEGAL, MEDIA, IG
- UTILIZES
  - FACILITIES OF 14 COMMON CARRIERS IN 13 STATES
  - FACILITIES OF 6 SPECIALIZED COMMON CARRIERS IN 6 STATES
  - 388 DIFFERENT TYPES OF COMPUTERS AND TERMINALS
- DATA RATES FROM 110 B/S TO 56 KB/S
- 510 MAILBOXES ON TELEMAIL NASANET
- NETWORK CONTROL AT MSFC

NASA HQ TCSD-3487 (1)
6-23-83

17

The next slide (figure 17) gets into what I will call our other network. It's a much smaller activity. It carries what we call program-support communications. It's all those nonoperational communications activities. The Nascom network operates under a waiver from the GSA; in that we are able to operate the Nascom network without GSA involvement. This nonoperational communications falls under the purview of GSA approval and involvement and is, at least, one reason that it's separate. It's about 350 circuit miles and carries mainly on voice teleconference system that we utilize to very great effect and a great deal of utilization. We expect over 4,500 voice teleconferences over that system in fiscal year 1983. We have high-speed faxes that tie those locations together so that we can move our presentation material almost in real time as we're carrying out teleconferences. The low speed fax system for moving things that are not as high of a priority as the high-speed fax. We've gone to a package switch network for some of our special purpose activities, such as a shuttle data. We have a legal network tied into a legal data base that at, believe the University of Wisconsin. The media, our press releases can be package switched to all of our locations and the Inspector General has all of their activities into a network that can provide up-to-date information on their activities from location to location. Again this is a lease system. Data rates up to 56 kilobits.

We are beginning to utilize electronic mail, again to great advantage and we have about 500 mail boxes on the telemail system which is a commercial system operated by GTE. The NASA net is just a NASA way of controlling access of the NASA people to that

telegram network and control the growth and the cost. The network control of this system is partial.

NASA TELECOMMUNICATIONS

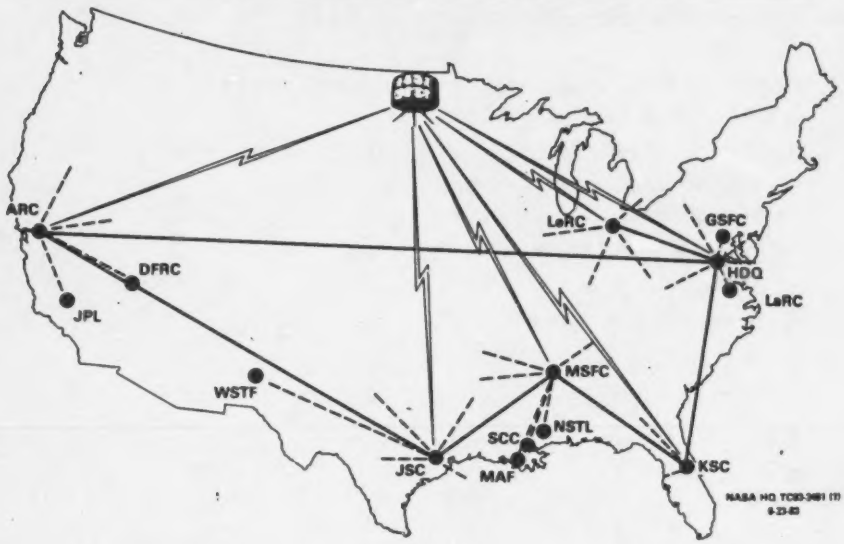
PSC - WHAT IT MAY BECOME - THE "PROGRAM SUPPORT COMMUNICATIONS NETWORK (PSCN)"

- COMMON USER INTEGRATED NETWORK CONSISTING OF
  - GATEWAYS - 14 LOCATIONS IN INITIAL NETWORK
  - TRANSMISSION CHANNEL - AT LEAST 1.5 MB/S CAPACITY
  - NETWORK CONTROL CENTER - LOCATED AT MSFC
- WILL PROVIDE -
  - ALL CURRENT SERVICES OF PSC
  - +
  - SUPER COMPUTER DATA LINKS
  - +
  - VIDEO TELECONFERENCING
  - +
  - FTS SERVICE BETWEEN NASA FACILITIES
  - +
  - FTS SUPPORT TO GSA

NASA HQ TCSD 2684 (1)
8-23-82

18

PROGRAM SUPPORT COMMUNICATIONS FUTURE NETWORK



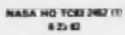
19

We're in the process of—that system has built-up over the last 10 years or so, in a sort of piecemeal basis. It's never been a network in the same nature as NASCOM has been. We believe it is time that we systematize that network (figures 18 and 19) in the same way that we have NASCOM and take advantage of the competitive marketplace and the modern digital systems and multiplexing ability to get a much better operational network. We will do that through—this is a concept, not necessarily exactly what we will do—gateways which is a really sophisticated switch in computer, or not-so sophisticated in some places, in the initial network at NASA locations. The transmission channel will be at least 1½ megabits, at between some locations, so that we can interconnect some of the larger computers at the research centers. And, the network control center again will be at Marshall. The things that it will do that the other network didn't address is to have the computer-to-computer link at the high data rate, have an ability of a video teleconferencing between locations and we will likely—and we will have worked with FTS on this—have put the NASA voice FTS traffic on this network. And also to the degree that it has capacity to have other FTS voice traffic, we would take that into this network through our switches for the GSA on a reimbursable basis.

NASA TELECOMMUNICATIONS

RADIO SPECTRUM MANAGEMENT

- OBJECTIVE - TO ASSURE AVAILABILITY OF ADEQUATE AND APPROPRIATE SPECTRUM RESOURCES FOR NASA PROGRAMS.
- NASA HAS MANY UNIQUE REQUIREMENTS
  - TDRSS
  - EARTH RESOURCES
  - SHUTTLE
  - DEEP SPACE
  - VLBI
  - EXPLORERS
  - MET SATS
  - AERONAUTICS
  - BALLOONS
  - SETI
- MUST OPERATE IN TOTALLY REGULATED ENVIRONMENT NATIONALLY AND INTERNATIONALLY.
- SUCCESS DEPENDS ON COORDINATION AND NEGOTIATION.
- OMB REGULATIONS REQUIRE GUARANTEED SPECTRUM ACCOMMODATION BEFORE DEVELOPMENT.



20

Next slide (figure 20) is radio spectrum management. That sounds sort of mundane, but it's a very large activity. We have about, we have 1450 frequency assignments to the program activities of the Agency. About 200 assignments with the shuttle alone and every one of these we have to manage in a way that we're sure that we have clearance to utilize that spectrum and that frequency in that location for that purpose and do not interfere with or affect other users of the spectrum in those locations. So it's a complicated thing that we have to do in following that. We also have to be concerned internationally about the protection of frequencies to carry-out our research program. We are involved in the ITU activities, international telecommunication activities, as well as those in the domestic United States.

MISSION CONTROL SYSTEMS PLANNING

- IMPLEMENTATION OF OPERATIONAL CONTROL CAPABILITY FOR THE SPACE TELESCOPE IN PROGRESS
- MISSION CONTROL SYSTEMS DEVELOPMENTS UNDERWAY FOR:
  - ERBS/SMM REPAIR – HARDWARE AND SOFTWARE SYSTEMS DESIGNS COMPLETE – SYSTEM IMPLEMENTATION INITIATED
  - GRO/COBE/UARS – SUPPORT REQUIREMENTS DEFINED, SYSTEMS STUDIES IN PROGRESS
- ESTABLISHING AUTOMATED MISSION CONTROL FACILITIES
- STUDYING AND ASSESSING USER DISTRIBUTED EXPERIMENT CONTROL CAPABILITIES
  - CONTRACTED FOR FUNCTION DESIGN
  - TECHNIQUES APPLICABLE FOR SPACE STATION/PLATFORM PAYLOADS

NASA HQ TC83-2794 (1); 7-14-83 21

Next slide (figure 21) addresses mission control system planning. I will skip through these fairly rapidly. Mostly what we're doing is developing the ability to support multiple missions from a given mission control location. We have one multimission control center currently in operation handling eight missions in real time. Sometimes we have dedicated control centers for very large programs of very long duration, space telescope's an example of that. It has a dedicated control system center. We're developing that currently.

MISSION SUPPORT COMPUTING

- MODERNIZE MISSION SUPPORT COMPUTER SYSTEMS
  - COMPLETE A COMPREHENSIVE PROGRAM TO REPLACE AGING COMPUTER SYSTEMS THAT HAVE BECOME COSTLY TO OPERATE AND MAINTAIN.
  - INCORPORATE NEW AND MORE EFFICIENT SOFTWARE TO PERFORM COMPUTATIONS NEEDED TO SUPPORT MISSION OPERATIONS AND CONTROL OF SPACECRAFT

NASA HQ TC83-2798 (1)
Rev. 7-25-83

22

OVERALL DATA SYSTEMS PLANNING CONTINUING ACTIVITIES

- SPACE STATION
  - END TO END INFORMATION SYSTEM STUDY BEING CONDUCTED AT JPL.
  - PRELIMINARY USER NEEDS INDENTIFIED AND SYSTEM ARCHITECTURE CONCEPTUALIZED.
  - FUTURE WORK WILL INCLUDE GROUND/SPACE TRADE-OFF STUDIES
  - INCREASED CENTER PARTICIPATION IN FOLLOW-ON STUDIES

NASA HQ TS3-3441 (1)
8-29-83

23

ADVANCED SYSTEM ACTIVITIES

- MAJOR STUDIES AND DEVELOPMENTS TO AID USERS OF DATA RELAY SATELLITE AND DEEP SPACE NETWORK
  - IMPROVED TDRSS TRANSPONDER
  - 20 M b/s SPACECRAFT TAPE RECORDER
  - JOINT DEVELOPMENT OF X-BAND TRANSPONDER FOR DEEP SPACE
  - 34 METER K-BAND R&D ANTENNA
  - TDRSS FOLLOW-ON

24

Next (figure 22), our mission-support computers, those computers that do our command management and our orbit calculations and our other computerized calculations related to mission support, are in the process of being replaced. We're about halfway through that and we'll finish that over the next several years. In our future programs (figure 23), we are sponsoring and involved the information system and mission control system studies for the space station. We have sponsored some work at JPL and a coordinating network with the other NASA centers that are working in this area. In advance systems activities, (figure 24) we are just making sure we are pursuing those technologies important to the future. We have, I think a very healthy program that we really cannot get into in detail at the time allowed here, so I'll just hit on a few high points. What is the tracking and data relay satellite transponder? That is the device that goes in the spacecraft that the tracking and data relay satellite communicates with. Since the program started in 1976, it was intended to be operational in 1979 and now it will be 1983 or 1984. The transponder that was developed back in the late 1970's to be utilized in those spacecraft, such as Landsat, is sort of behind the state-of-the-art now and even to the point where you can't build it. We're improving that through a design upgrade, such that the future programs will have available to it a good TDRSS transponder to use with the tracking and data relay satellite system.

There are many spacecraft that operate at a data rate that does not utilize the full band-width of the tracking and data relay satellite system. One way to get better utilization of the tracking and data relay satellite is to somehow get that data rate up. One way is to use a tape recorder to record at a low rate and play it back at the high rate, at 20 megabits. If a spacecraft is operating at one megabit, if we can collect that data over a period of some hours and play it back through TDRSS, at 20 megabits, we've cut the utilization of that very valuable link by a factor of 20. So we are spon-

soring the development of the tape recorder for some of those kinds of applications. We have available for deep space communication, the X-band frequency spectrum. We have implemented as a down link in the DSN. We are presently in the process of implementing up link capability. In other words, command, in sending of data up to spacecraft at X-band, currently we use S. In order for that to become usable, there must be a transponder put into the spacecraft. We are jointly developing that with the space science and applications organization.

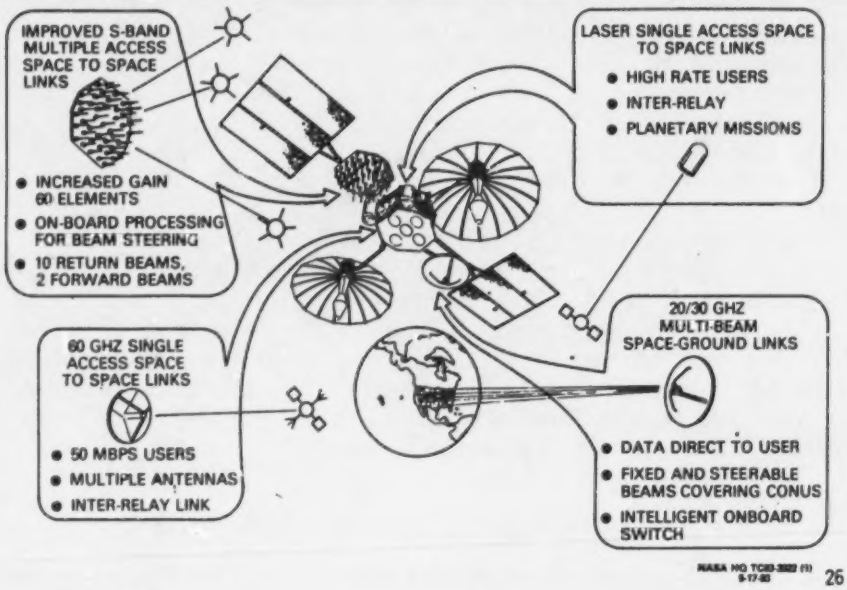
Our research for the DSN over the last 15 to 20 years has been done with a research antenna that we have at Goldstone in California. It has reached the limits of its ability to support research. It's an S-band antenna, some X-band capability. We need to start doing research at K-band. That's a new frequency opened up at the World Administrative Radio Congress for deep space. We need to do other research in the frequency spectrum and the K-band spectrum and we will require at some point, a new research antenna to do that. We will be coming forth with a proposal at some time to build a new research antenna to support that activity.

ADVANCED SYSTEMS ACTIVITIES

- TRACKING AND DATA ACQUISITION SYSTEM (TDAS); TDRSS FOLLOW-ON
  - TWO YEAR STUDY WITH STI NEARING COMPLETION
  - FUTURE SPACE MISSION DATA NEEDS STUDIED
    - NASA MISSIONS IN 300-800 Mb/s RANGE FORSEEN
  - CANDIDATE SPACECRAFT ARCHITECTURES PROPOSED
  - TDAS CONSTELLATIONS EXAMINED
  - TECHNOLOGY NEEDED FOR SYSTEMS DEFINITION IDENTIFIED
    - W-BAND (60 GHz) SYSTEMS
    - MULTI-BEAM ANTENNA SWITCHING
    - LASER SPACE-TO-SPACE LINK
    - R-F GROUND TERMINAL (DISTRIBUTED)
    - TDAS SYSTEMS DEFINITION AND ANALYSIS
  - TECHNOLOGY STUDIES TO START IN FY 1984

NASA HQ TCSD-2017 (1) 5-17-83 25

TDAS TECHNOLOGY


IMPROVED S-BAND MULTIPLE ACCESS SPACE TO SPACE LINKS
• INCREASED GAIN 60 ELEMENTS
• ON-BOARD PROCESSING FOR BEAM STEERING
• 10 RETURN BEAMS, 2 FORWARD BEAMS
LASER SINGLE ACCESS SPACE TO SPACE LINKS
• HIGH RATE USERS
• INTER-RELAY
• PLANETARY MISSIONS
20/30 GHZ MULTI-BEAM SPACE-GROUND LINKS
• DATA DIRECT TO USER
• FIXED AND STEERABLE BEAMS COVERING CONUS
• INTELLIGENT ONBOARD SWITCH
60 GHZ SINGLE ACCESS SPACE TO SPACE LINKS
• 50 MBPS USERS
• MULTIPLE ANTENNAS
• INTER-RELAY LINK
NASA HQ TDRS-3502 (1) 5-17-83
26

It's not too early to begin to think about what will come after the tracking and data relay satellite system, even though we are in the throes of attempting to bring it to its initial operation. It takes some 10 to 15 years to bring a new system to fruition from the point of just initial studies. Also, through the contract reformation, we have available to us six spacecraft of the TDRSS vintage and it may be wise to consider modifying some of the later spacecraft in that series for increased capability. That would probably be spacecraft five and six. So we're engaged in studies to see where we might be headed after TDRSS and we've called that Tidas (figures 25 and 26). I'm not sure I like that very much, but that's what it's been called so far. Some of the things that we might consider would be higher-frequency space-to-space link, either at 60 gigahertz or possibly laser, to get higher data rates from user satellites. Some of the space platforms that are talked about in the space science and applications program and the space station program would require some of these data rates probably in the mid-1990's. That would require the higher frequencies.

The other is a higher-frequency space-to-ground link. We're currently T-band 14 gigahertz and we might consider going to 20 to 30 gigahertz or maybe even higher for the space to ground link. Also, there's no technical reason that we have to bring all the data to a single location, such as White Sands, and then redistribute it to those who need it. It's technically feasible to consider spot beams directing that ground link to the location where the user is and take it straight to him or her rather than to a single location and redistributing it.

So those are some of the concepts that we are looking at. We are in the very early stages of doing this and we've not developed a specific program plan. As we do, we will come with that, of course, to the Congress. I believe that ends what I have prepared to discuss with you and I'm available to answer questions.

Mr. VOLKMER. Thank you very much, Mr. Smylie. I have some questions and I won't go through them all because the time is such that we have one witness to go. But I will— those that I get to this time, I'll send them to you in writing and request that you respond if that's possible

Mr. SMYLIE. Yes, sir, we'd be pleased to——

Mr. VOLKMER. I think we've already pretty well covered the checkout of the TDRSS—and how that's going and look forward to making sure that that checks out. Guess there is a possibility that things don't check out as you're hoping they do—that may influence the data launch of nine then, would it not?

Mr. SMYLIE. Yes, sir, that is possible and probably even likely. We have not at this point made a final decision on that.

Mr. VOLKMER. On the C-band of the TDRSS which is now dedicated to the Government. You talked about that a little bit. What are the possibilities of use on that?

Mr. SMYLIE. Well, it's—from a technical point of view, it's certainly a feasible thing to do. And, I think there are communications needs that it could serve very well for NASA, the DOD and possibly other Government agencies. The ability of the Government to use a commercial band, I think it's possible to do that. We've not gone through all the activities necessary to get approval to do that. We've not even gone forward with a request to do that, and won't until we really understand what our proposed utilization would be. We would have to go to some other Government agencies. And, I believe it would be prudent to come up and talk to the congressional committees before we did anything like that. So as our plans develop along those lines, we would discuss them with the committees.

Mr. VOLKMER. Would these be communications, in other words, replace any that you presently have, as a possibility?

Mr. SMYLIE. Potentially, we currently move data from White Sands to Goddard and JSC via a domestic satellite and TDRSS could do that job.

Mr. VOLKMER. But you would discuss it with the Congress before you went ahead——

Mr. SMYLIE. Yes, sir. I think that would be prudent for us to do that.

Mr. VOLKMER. If you utilize—if other agencies utilized, whoever they may be—I would think that there may be a possibility then for reimbursement on that?

Mr. SMYLIE. Yes, sir.

Mr. VOLKMER. Have you talked to DOD about this at all?

Mr. SMYLIE. Yes, sir. We do have discussions with the DOD and the USIA on potential utilization of this service in identifying opportunities, requirements, and so forth. That is sort of a joint effort between the three agencies, primarily the DOD though.

Mr. VOLKMER. Now the ground network systems. We're going to have to delay the closing of those, there's no question about that.

What budget implications does this mean? We've already done 1984 and everything and that takes us to September and you're looking at possibly doing this September, instead of April. Are you going to have enough money to operate?

Mr. SMYLIE. Sir, we do have significant fiscal year budget problems in carrying out not only because the slip of the second launch of TDRSS has a budget impact, because of the activities, number one necessary to recover the A-satellite, but to carry the checkout teams longer for the delayed launch. So the combination of those things does create a budget problem for us. We have handled that through an extension of the borrowing from the FFB. As you may recall, we had planned to end that borrowing period early next year. We would stem that borrowing through the end of the fiscal year. Then we will reprogram—we will come to the Congress with a request to reprogram some money from the appropriated funds for the TDRSS program in fiscal year 1984 into the extension of the ground networks. We have been up and talked to the staff of all four committees about that. There are several actions we have to take with the committees as soon as we fully understand the situation and formalize how we can do that. But we can cover the 1984 problem that way. In the fiscal 1985 budget, to what extent it is impacted by this situation, we will request as part of our appropriations and authorization.

Mr. VOLKMER. Now I assume that all the effective personnel have been notified of the new data so that they know that they're going to stay on a little longer.

Mr. SMYLIE. Yes, sir. We sent out notice some time ago, letting the stations know that we were going to extend them to the September timeframe, at least.

Mr. VOLKMER. How many of these stations that are being closed will be dismantled and how many will remain—what's going to happen to some of them.

Mr. SMYLIE. Some of that's under discussion. It's not fully decided. I believe that the station in Hawaii will remain and be operated by some element of the DOD, either the Air Force or the Navy, or a combination of the two. It's likely the station in Guam will be utilized by the Air Force. Ascension Island probably will be dismantled. The Santiago, Chile, station—certainly some of the Chileans would like to operate it as a Landsat station. Whether they'll be able to do that or not, I don't know. Our country-to-country agreement allows them to take over those assets, I believe to the degree that we don't need them. We will not need much of that, we're not going to bring much of that out. The Dakar station is very small, almost mobile, and we would probably dismantle that. The Botswana station, same thing, it's voice only. It's very—in fact, its equipment in the room of the Intelsat ground station there, it occupies just a few racks of equipment. The same in Australia—that's in a trailer colocated with a Landsat receiving station that the Australians operate. We'll just shut that down. I believe that covers—the Alaska station will be taken over by NOAA and continue to be used to support their weather satellites.

Mr. VOLKMER. Now as I understand it, some of the problems of upgrading the computer—is the data, the amount of the data that

we have flowing through the system, so I've been told, the data over in Goddard still to be analyzed.

Mr. SMYLIE. Well, that's probably always true that you get more data than you're ever able to fully analyze, although many researchers and graduate students go back and look at data years and years later and extract new scientific information from it. We had a lot of trouble some years ago processing Landsat data in the form allowed us to stay up with it. We built a very large backlog of data. We have since worked that off and are pretty well caught up. The data, of course, is delivered to the U.S. data center in Sioux Falls and is available as an archive to anyone who needs it.

Our job is to capture the data, organize it in a fashion that it can be delivered to the researcher for his use and that's where our job pretty much ends. I don't have any good knowledge as to whether there's all that much stacked up or not, because we've given it to somebody. We don't have it.

Mr. VOLKMER. What about—how much data will be generated by the TDRSS?

Mr. SMYLIE. TDRSS is a relay, but it certainly has the capacity to pass a tremendous amount of data through that system. Spacelab and its flight can produce an average, I guess, of 50 megabits of data per second over its flight. We can capture that, we can demultiplex it, we can put it on tape, and we can give it to the experimenters. We have the capacity to do that, same with space telescope. It runs about one megabit. We have put in place a system that will capture it, process it and send it to the Space Telescope Institute.

Mr. VOLKMER. Same way if we get Landsat, and get going, you can be able to process that? Turn it over to the NOAA?

Mr. SMYLIE. I think you're asking a question as to whether the researchers can absorb all that data and extract anything useful out of it. That's, I believe that they can, but my job sort of ends when I give it to them, and it's up to them to get something useful out of it.

Mr. VOLKMER. So you're able to—you feel you'll be able at least to handle it and transfer it.

Mr. SMYLIE. Yes, sir, I think so. One thing we're doing to improve our capability to do that is White Sands, of course, can take in data at a faster rate than we can move it out of White Sands right now. We are working with a domestic communications satellites where we believe they can upgrade their capability to pass that data from White Sands back to somewhere else in a better way than they can today. But that's not a significant problem.

Mr. VOLKMER. Now, does NASA plan to propose any more off-budget financing, as was done for the TDRSS?

Mr. SMYLIE. I don't know of any that NASA is planning. I believe the Congress has closed that door; I don't think we'll able to do that.

Mr. VOLKMER. Now, the question of any noncommercial use for C-band transponders—it'll all be commercial basically, if you use them for a government agency.

Mr. SMYLIE. Actually, it's in a commercial band and that's what the word commercial means really, is that frequency is reserved for commercial purposes. Our use of it for government use could also

be called commercial, because we go out and purchase that capacity right now on the market. Our planning right now is for government agency use of that capacity. We are not considering at this time selling those transponders to somebody else to go out and then market it to other commercial interests. That'll sort of get us, in principle, back into the situation that we with such pain got out of when we restructured that contract.

Mr. VOLKMER. Since that would be on a commercial band, I don't know if it would be known or unknown as to the frequency. But couldn't anybody else just pick that up?

Mr. SMYLIE. They can receive it if they put in the proper receiving station in tune to that frequency and if the person who is sending that information has not encripted in any way. Just as you can receive TV stations now. If you want to go out and build your own antenna and point it at a domestic satellite, you can receive TV. I assume the same is true of what comes from the satellite.

Mr. VOLKMER. If you use that C-band. Is there any possibility of using a C-band for intersatellite communication.

Mr. SMYLIE. No, sir. It's not suitable for that. It's not pointed the right way and it's not a frequency band that is utilized for that purpose. There's nothing up there that it could work with that way.

Mr. VOLKMER. Does Spacecom own the facilities or equipment at White Sands?

Mr. SMYLIE. Yes, sir. They own it all. They virtually own it. There's one Wang, they call the Government Wang that has Government equipment in it, but just about everything else Spacecom has title to.

Mr. VOLKMER. Since you're no longer considering adopting the TDRSS to beam to the Pacific, what is the status of the proposal to put the TDRSS beam on Europe?

Mr. SMYLIE. Well, part of what we're doing in this activity with the DOD is considering a possibility and a requirement for communications trans-Atlantic, from the East Coast to Western Europe. Also USIA has such a requirement that they would like to see satisfied. We believe that by some minimal repointing of the C-band feeds on the satellite that we could accomplish trans-Atlantic communications to satisfy that requirement. If we were to do that, that same satellite, the same design that had been reconfigured for trans-Atlantic communications, if you placed it over the Pacific where we will eventually put a satellite, it would be able to carry communications from the West Coast to the Japan, Korea area. That's just serendipity. It just turns out that way and that also has some interest to the DOD and possibly other Government agencies. Nothing we're doing would satisfy the transmission of communications into the South Pacific. That requires a different kind of design change. That would make the satellite completely unusable for any other use but that, commercial band.

[Questions and answers submitted for the record follow:]

Written responses to questions submitted by Chairman Volkmer during the hearing on July 28, 1983, at which Mr. Smylie testified on the Office of Space Tracking and Data Systems' five-year plan.

QUESTION T-1:

Since most of the circuits and switches are leased by NASA--

a. What has been the lease cost per year for this system?

b. How long has it taken to build this system?

ANSWER T-1:

a. The lease cost for FY 1983 is $43.2 million.

b. The system was initially built in 1962 and has been characterized by changing communications requirements in support of major space flight missions. This has been an evolutionary process beginning with the Mercury project and finally leading up to the present Space Shuttle mission requirements.

For example, from 1962 - 1967 low bit rate, voice bandwidth, high frequency radio circuits and voice bandwidth cable circuits were utilized for Project Mercury. Today, for Space Shuttle missions multimegabit bandwidth circuits and switching facilities are being used.

QUESTION T-2:

a. Do you intend to use the TDRSS for this role in the future?

b. How much will the TDRSS save?

c. How will the costs be stabilized?

d. Will these cost figures be over and above the TDRSS Operations and Maintenance costs?

ANSWER T-2:

a. The C-band transponders are planned to be retained on the spacecraft. There may be ways within appropriate regulations for NASA and other Government agencies to take advantage of that capacity. NASA, the DOD and the USIA are currently working with the NTIA to explore the potential for using this capacity.

b. Based on the current market value, each C-band (fully backed-up) transponder could save about $1.8 million per year in space segment costs. The number of transponders used would depend on the services that

could be appropriately provided in keeping with a policy of preemptibility for the prime mission of the satellites.

c. Costs would be stabilized because the value of the transponders would not be subject to market place or regulatory tariff increases.

d. There will be little or no additional costs over the TDRSS Operations and Maintenance costs to operate the C-band transponders in the spacecraft. Ground terminal costs associated with the use of the C-band transponders will be additional, however.

QUESTION T-3:

What is your overall philosophy or guidelines regarding Mission Control facilities?

a. Are we going to have mission control rooms for every exotic mission or experimen.?

b. Are we going to have a mission control room at the Space Telescope Institute as well? What is the criteria for these facilities?

c. What are the costs associated with these types of activities?

ANSWER T-3:

The overall philosophy regarding Mission Control Facilities is to use the Multi-Satellite Operations Control Center (MSOCC) whenever spacecraft monitor and control requirements are sporadic, and to use a dedicated control center when the monitor and control requirements are continuous and approach a one hundred percent duty cycle.

a. No. We are currently studying and defining distributed Mission Operations functions which will allow Mission Operations Rooms to be essentially remoted to the experimenter's facility utilizing the experimenter's equipments. Through distributed Mission Planning Scheduling and Control, unique centralized Mission Operations Rooms will not be required in the era of numerous short lived, quick turnaround experiments as will be experienced with Shuttle attached payloads, space platforms and space stations. Some spacecraft, such as the Space Telescope, are provided a dedicated control center. Ground operations of the Space Telescope are extremely complicated involving the high precision telescope pointing, the manipulation of the several experimental packages on board, the pointing of the spacecraft antenna toward the TDRSS, and the energy and momentum management of the vehicle itself.

b. The Space Telescope Institute does not have a Mission Operations Room per se, but will be capable of monitoring the telescope operations and transferring commands to the Space Telescope Control Center which has overall responsibility for the health, safety, and operations of the Space Telescope vehicle.

c. In the case of MSOCC, each new Mission Operations Room is a rehabilitated Mission Operations Room previously used by a spacecraft no longer being supported. Typically, $100 to $200 thousand is spent in the rehabilitation.

Mr. VOLKMER. Thank you very much, Mr. Smylie. We have no other questions for you at this time.

Our final witness is Dr. Raymond S. Colladay, Associate Administrator, Office of Aeronautics and Space Technology.

Dr. Colladay, as I understand, you, too, are going to use viewgraphs, is that right?

Dr. COLLADAY. That's right, Mr. Chairman.

I'll summarize our technology plans by going through a few viewgraphs.

STATEMENT OF DR. RAYMOND S. COLLADAY, ACTING ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Dr. COLLADAY. I think it's appropriate that I bring up the rear when we talk about the advanced technology program, although I'm sure none of us expected that the rear would be this far back or this late. [Laughter.]

Dr. COLLADAY. Or this late. I'm sorry.

Mr. VOLKMER. I have to apologize.

Dr. COLLADAY. That's all right.

Mr. VOLKMER. There's too much going on over at NASA.

Dr. COLLADAY. Well, it is exciting and there is a lot going on. We feel that the advanced technology program really provides the building blocks to realize some of these future opportunities that you've been hearing about in the program briefings Tuesday and today.

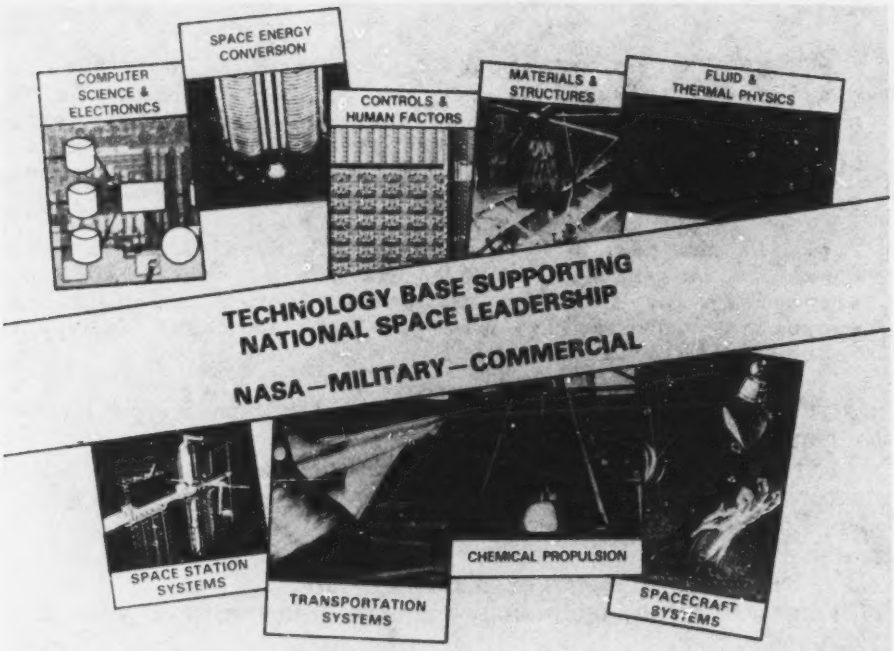


Figure 3

This is the part of the program, as you know, that it is—in the advanced technology effort, that is not directed at any specific project or program that you heard discussed but is rather broad and generic in scope to try and lay the foundation for future opportunities. I am suggesting by the banner on this chart (figure 3) that that role should go beyond NASA, given the growing involvement in space of military and commercial applications and the technology program, we feel should provide a national role. The areas that we are working on—computer science and electronics, space power, controls and human factors, as well as across the bottom, some of the systems and subsystems areas.

SPACE R&T LONG RANGE OBJECTIVES

- MAINTAIN NASA CENTERS IN POSITIONS OF EXCELLENCE IN FACILITIES, TECHNICAL STAFF, AND COMPUTATIONAL CAPABILITY
- ENSURE THE TIMELY PROVISION OF NEW CONCEPTS AND ADVANCED TECHNOLOGY FOR U.S. CIVIL AND MILITARY SPACE ACTIVITIES
- ENSURE BROAD PARTICIPATION OF INDUSTRY AND UNIVERSITIES IN NASA SPACE R&T PROGRAM
- IMPROVE THE TRANSFER OF RESEARCH RESULTS TO THE SPACECRAFT INDUSTRY
- PROVIDE SUPPORT TO THE DEVELOPMENT PHASE OF SPACE ACTIVITIES OF OTHER GOVERNMENT AGENCIES, U.S. INDUSTRY, AND TO NASA FLIGHT PROJECTS

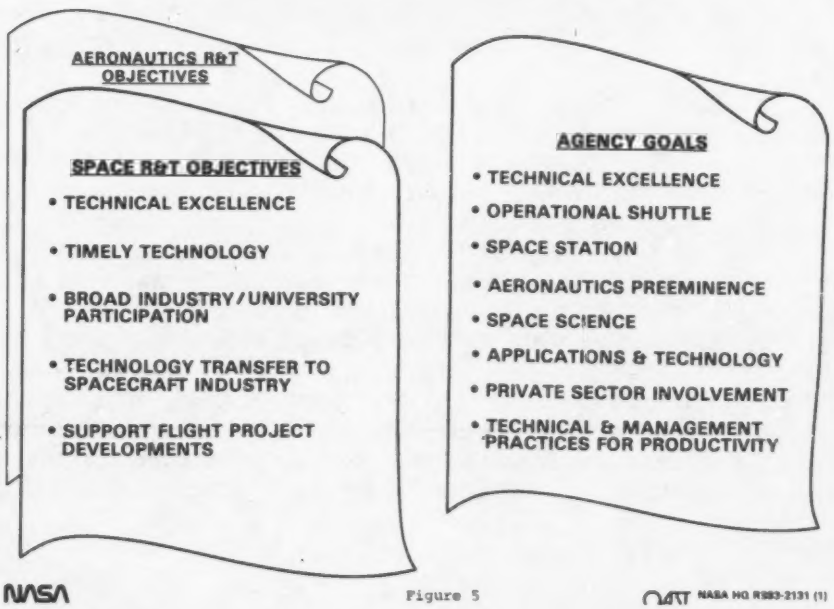
NASA OAST

Figure 4

In meeting that overall goal for the space technology program, the next chart (figure 4) summarizes the specific space R&T long-range objectives. The first and foremost of those five objectives focuses in on the health of the institution and creating an environment conducive to advanced research and technology, providing excellence of facilities to support the program and technical staff.

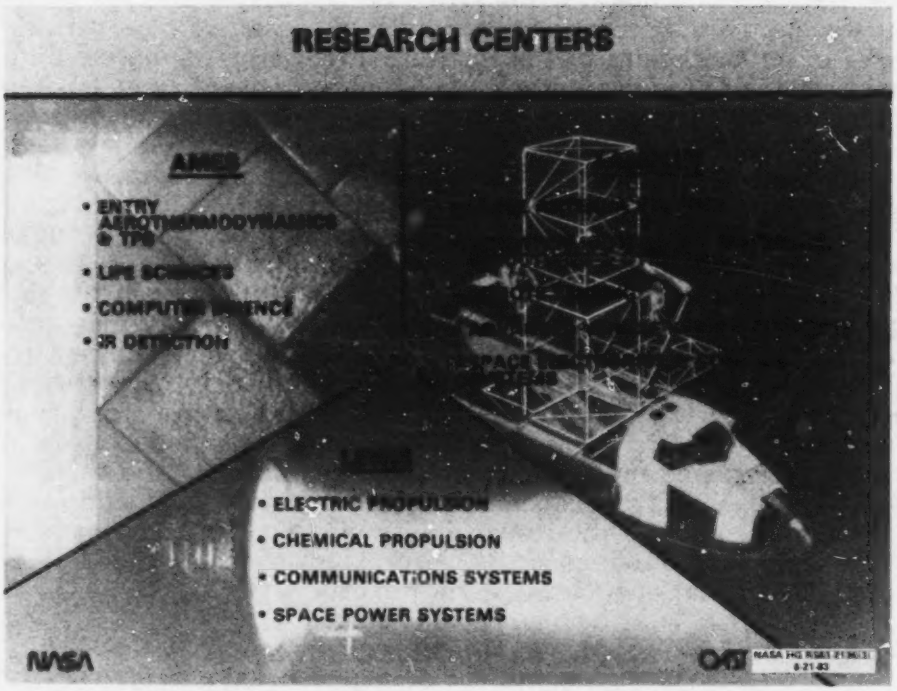
We've made, as you are probably aware, a great deal of progress, we feel, in being able to hire new scientists and engineers this year, fresh out of college and I am happy to say that, of the Agency's total for this fiscal year, in the research area, we've brought over half of those in the centers of Ames, Langley, and Lewis. Through that maintenance, then, of the institution, then we can embark on the next long-range objective of insuring the timely provision of new concepts, supporting both U.S. civil and military activities. And, we think it's very important to broaden the participation of the industry and universities in the R&T program and that helps in the transfer of the results to the spacecraft industry, both the manufacturing industry and the user community. And then, finally, because we are custodians of some of the major facilities in the country, we have the responsibility of supporting development phases for space activities of the Government agencies, the U.S. industry, and to our own NASA flight projects.

OAST LRP OBJECTIVES
IN SUPPORT OF AGENCY GOALS



The next chart (figure 5) just racks up in shorthand form those five objectives. There is a similar set in the Office of Aeronautics and Space Technology for Aeronautical R&T and they, as you can see, pretty much one-to-one support the Agency goals that Mr. Beggs covered earlier on Tuesday.

Looking just briefly at the first objective—maintain centers of excellence, we do have a broadly based program and the next chart shows the areas of excellence in the research centers.



Next chart (figure 7), please—that report directly to the Office of Aeronautics and Space Technology. That's Ames, Langley, and Lewis.

And, at Langley, their key expertise is in large antenna systems and large structures, aerothermodynamics and the control of structures and analyzing the dynamics, remote sensing, advanced vehicle system concepts in analytical capability, and space electronics and control systems.

At Ames, we have long had a national center of excellence in entry aerothermodynamics and much of the thermal protection system early research for the shuttle tiles came out of the Ames work. Life sciences, as well, at Ames; computer science, and IR detection.

Lewis is our main center, as you know, for propulsion and power—electric propulsion, chemical propulsion as well as communications systems, and Lewis is the center responsible for the advanced communication satellite technology program that Burt talked about.

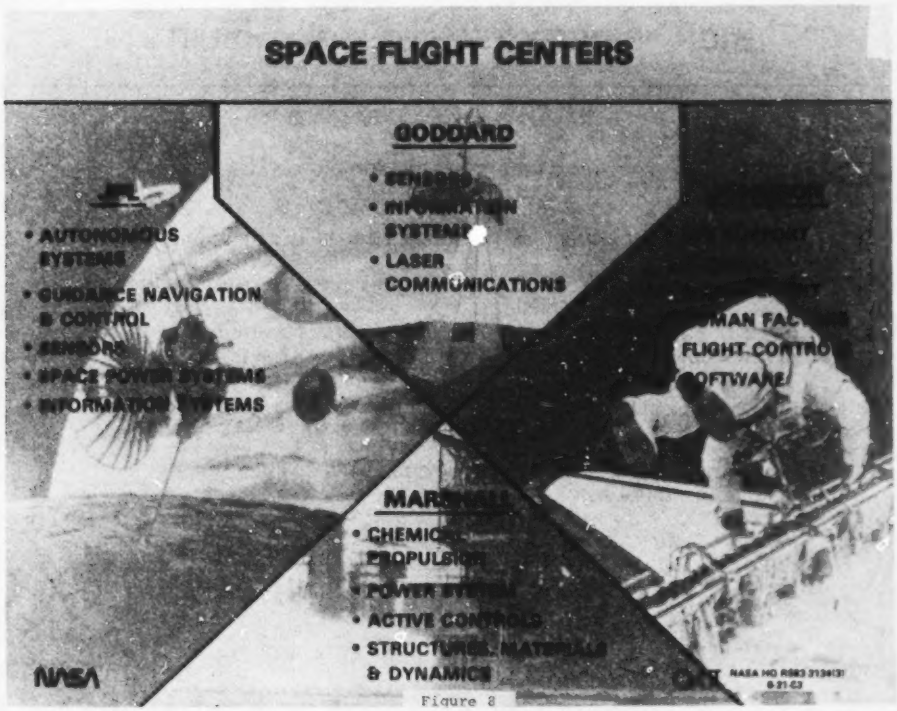


Figure 8

The next chart (figure 8) illustrates the extent of our technology program in the space flight centers. And, even though the space flight centers report to other program offices, we do have a broadly based technology effort at these four centers and also at Kennedy—which isn't on there, but has some technology ongoing in operations. JPL in autonomous systems and guidance and control, sensors and space power systems; Goddard in sensors and information systems; Johnson, companion with Ames, in life support, thermal management, human factors; and Marshall working closely with Lewis in chemical propulsion, power systems and structures.

HIGH PRIORITY TECHNOLOGY THRUSTS

- PROVIDE NEW MATERIALS AND CONCEPTS FOR ORBITER THERMAL PROTECTION
- ADVANCE THE TECHNOLOGIES TO ENABLE LONGER-LIFE REUSABLE ENGINES
- PROVIDE THE TECHNOLOGY FOR OTV PROPULSION AND AEROBRAKING
- DEVELOP COMPUTATIONAL FLUID DYNAMICS (CFD) TECHNIQUES FOR APPLICATION TO ENTRY BODY AND ROCKET ENGINE DESIGN
- EVOLVE THE CAPABILITY FOR HIGH CAPACITY ELECTRICAL POWER GENERATION, STORAGE, AND DISTRIBUTION SYSTEMS
- GENERATE THE TECHNOLOGY BASE IN COMPUTER SCIENCE FOR AEROSPACE APPLICATIONS
- IMPROVE SPACE INFORMATION MANAGEMENT THROUGH SMART SENSORS, ONBOARD DATA PROCESSORS, SOFTWARE, SYSTEM ARCHITECTURE, AND GROUND SYSTEMS

NASA Figure 10 OAST

Moving on quickly now to the second objective in summarizing the next chart (figure 10), the high priority technology thrusts in the program—could I have the next chart, please—what we have done in terms of identifying what the real important drivers are that we think in the 5 year—5- to 10-year period that set the direction for the technology effort; then, provide a road map for our investment of resources, as well as to communicate to the people that are involved in the program where we think the important emphasis should be placed.

These are summarized in these next two charts as well as in more detail on the following 12 charts, the first one providing new materials and concepts for orbiter thermal protection systems. We are looking to increase the mission life of TPS materials to 300 missions in all-weather operation; advancing technologies to enable longer-life reusable engines. This is certainly a technology feat that we can begin to approach, we think, in the future, aircraft engine durability and maintainability:

Providing technology for OTV propulsion as well as aerobraking that would be necessary in routine operation between geostationary orbit and low-Earth orbit is extremely important and the two drivers in that are the aerobraking and propulsion.

Developing computational fluid dynamics is a key technology driver and very synergistic with our aeronautics program for application not only in external flow entry research but in internal rocket engine design.

Evolving a capability for high capacity electrical power generation and storage is extremely important as we look to the future

expecting a need for utility power capability in space on the order of 100 kilowatts of power.

Generating technology base in computer science for highly reliable and high capacity systems.

Improving the information management through smart sensors and onboard data processing.

HIGH PRIORITY TECHNOLOGY THRUSTS
CONTINUED

- GENERATE THE TECHNOLOGY BASE FOR TELEOPERATOR AND AUTONOMOUS SPACE SYSTEMS
- ESTABLISH FEASIBILITY OF ADVANCED SENSOR CONCEPTS
- ADVANCE THE TECHNOLOGIES TO FULLY SUPPORT AND EXPLOIT HUMAN CAPABILITIES IN SPACE
- DEVELOP THE TECHNOLOGY TO ENABLE LARGE ANTENNA SYSTEMS
- ADVANCE THE TECHNOLOGY OF DISTRIBUTED, ADAPTIVE CONTROLS FOR LARGE SPACE SYSTEMS
- PROVIDE THE TECHNOLOGY FOR SATELLITE COMMUNICATIONS THROUGH RESEARCH IN ELECTRONIC COMPONENTS, SPACE AND GROUND SYSTEMS, AND PROPAGATION PHENOMENA

NASA Figure 11 OAST

Next chart, (figure 11)—Generating the technology base for teleoperation and autonomous space systems.

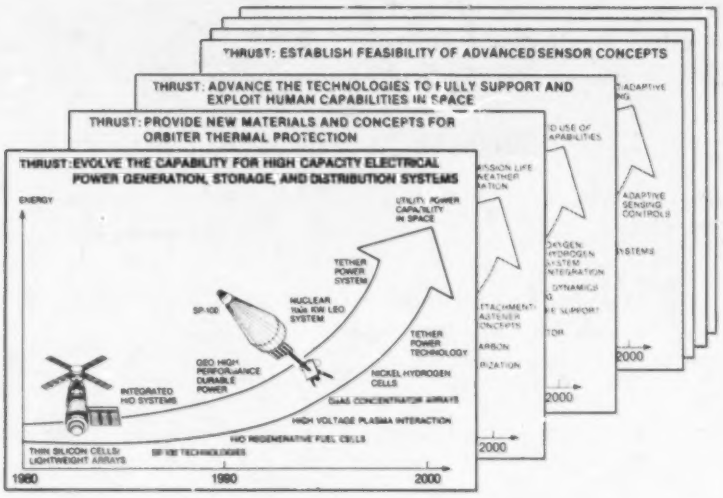
Striving to put in place the technology for intelligent autonomous systems.

Establishing feasibility of advanced sensor concepts where we work the front end basic sensor technology in a generic sense and then that's picked up by individual instruments and applications in space science and Earth resources.

Developing the technology to enable large antenna systems. That's structured in precision-shape control, very large structures that are not rigid and can be quite flexible. That is a close companion to the next technology goal in distributed, adaptive controls.

And, finally, in the area of communications, we provide base technology—research and technology products to feed into future communication as we did with the ACTS program where we laid the technology base prior to undertaking that important program and then we continued to look beyond that to advanced transmitters and receivers.

HIGH PRIORITY TECHNICAL THRUSTS


THRUST: ESTABLISH FEASIBILITY OF ADVANCED SENSOR CONCEPTS
THRUST: ADVANCE THE TECHNOLOGIES TO FULLY SUPPORT AND EXPLOIT HUMAN CAPABILITIES IN SPACE
THRUST: PROVIDE NEW MATERIALS AND CONCEPTS FOR ORBITER THERMAL PROTECTION
THRUST: EVOLVE THE CAPABILITY FOR HIGH CAPACITY ELECTRICAL POWER GENERATION, STORAGE, AND DISTRIBUTION SYSTEMS
ENERGY
UTILITY POWER CAPABILITY IN SPACE
TETHER POWER SYSTEM
SP-100
NUCLEAR 10kW FOR LEO SYSTEM
GEO HIGH PERFORMANCE DURABLE POWER
INTEGRATED H/O SYSTEMS
TETHER POWER TECHNOLOGY
NICKEL HYDROGEN CELLS
GaAs CONCENTRATOR ARRAYS
HIGH VOLTAGE PLASMA INTERACTION
H/O REGENERATIVE FUEL CELLS
THIN SILICON CELLS/ LIGHTWEIGHT ARRAYS
SP-100 TECHNOLOGIES
1980
1990
2000
2000
2000
2000

NASA

OAST NASA HQ RSD-2715 (1) 3-1-90

Chart A

The next chart (A) collapses in summary form—each of these 12 thrusts and they are included in your handout, where we provide against time where we see the technology going and use these, as I said, as a road map to set the direction of the program in the future.

You don't see any dollars against—any resources against these technology thrusts because we feel that they should stand the test of time and the rate at which we achieve the end objective is a function of the resources that we can apply against it.

But these are the principal areas that we are making the investment in the R&T program.

TECHNOLOGY FOCUS

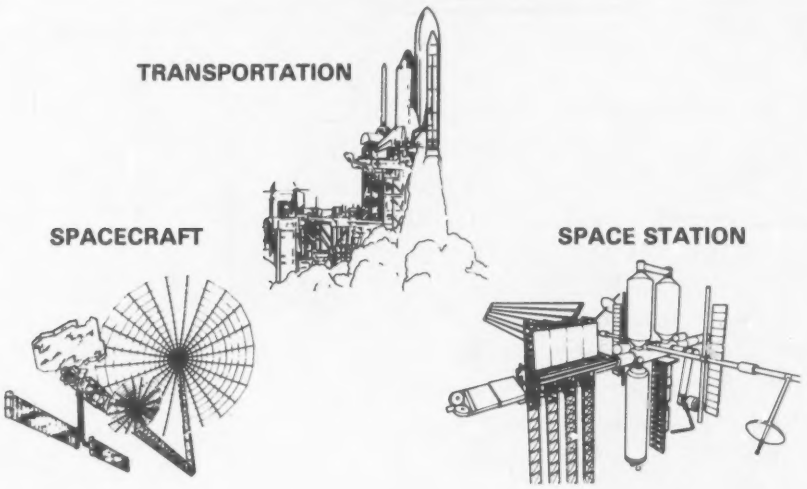


Figure 25

The next chart (figure 25) is helpful if I want to just switch gears and go through a transformation here and take these high priority technical thrusts and collapse them into the three principal focuses—system focuses that we deal with—spacecraft, transportation, and space station is an emerging area that I'll have more to say about.

HIGH PRIORITY TECHNOLOGY THRUSTS SUPPORT SYSTEM FOCUS

	SPACECRAFT	TRANSPORTATION	SPACE STATION
• TPS		X	
• LONGER-LIFE REUSABLE ENGINES		X	
• OTV PROPULSION & AEROBRAKING		X	
• COMPUTATIONAL FLUID DYNAMICS		X	
• HIGH CAPACITY ELECTRICAL POWER	X		X
• COMPUTER SCIENCE	X	X	X
• INFORMATION MANAGEMENT	X		X
• TELEOPERATOR & AUTONOMOUS SYSTEMS	X	X	X
• ADVANCED SENSOR CONCEPTS	X		
• HUMAN CAPABILITIES		X	X
• LARGE ANTENNA SYSTEMS	X		
• LARGE SPACE SYSTEM CONTROLS	X		X
• SATELLITE COMMUNICATIONS	X		X

NASA Figure 26 OAST NASA HQ R863-2223 (1) Rev. 6-27-83

The next chart (figure 26) shows each of those high priority thrusts along the left and then how they apply synergistically between these system focuses of spacecraft, transportation, and space station. You can see that, when we work discipline technology, it applies to a number of different systems.

The next six charts are in your handout and I won't go into detail, but it shows the areas of augmentation. If I lay the program against these systems, and I think the best way to deal with those augmentations is on a specific basis for 1985, 1986, and 1987 that I'll come to later.

In addition to those three system focus areas, we feel it is extremely important in the development of technology in the future to extend our ground-base laboratories into space environment. We feel we are in a position to, at this point in time to exploit the access into space that shuttles provide. And we need to be able—just as we use the shuttle for science experiments—we need to capitalize on the zero-G, radiation, vacuum environment of space to do technology development that is not possible to do on the ground.

If you think about control of large, complex structures that are flimsy and nonrigid, trying to develop the analytical tools to understand the behavior of these large structures on the ground is extremely difficult and we see a number of areas where we need to carry that laboratory into space using the shuttle. And, eventually, we hope space station will provide a laboratory environment where we can develop technology as well.

PROPOSED FY 1985 INITIATIVES

- IN-SPACE FLIGHT RESEARCH
  - SPACE STATION EMPHASIS
  - GENERIC APPLICABILITY
- SPACE STATION TECHNOLOGY
  - SSTSC RECOMMENDATIONS
  - EARLY FOCUS ON INITIAL STATION ENHANCING TECHNOLOGIES
- CHEMICAL PROPULSION TECHNOLOGY
  - JOINT OAST/OSF SSME TESTBED PROGRAMS
  - OTV CHEMICAL PROPULSION
- SPACECRAFT BUS TECHNOLOGY
  - NASA, COMMERCIAL AND DOD NEEDS
  - ASEB RECOMMENDATIONS

NASA

Figure 34

OAST NASA HQ R983-23368 (1) REV. 7.13.83

The first 1985 initiative (figure 34)—in fact is—that I have on the next chart—is in-space flight research. It has an early emphasis on exploring technology that is critical to possible space station application, but it isn't limited to that. There is generic applicability across the board. We have underway a number of technology areas that have been underway for a number of years that we have identified are applicable to space station. That doesn't mean that it was working technology uniquely associated with space station but, across the board, there are a number of areas that do support this effort.

Chemical propulsion technology is extremely important and we see a need to augment a program there in 1985 and I'll explain what we plan to do there—it's really in two areas—to carry some of the technology that's in the base program into an engine evaluation environment and also OTV chemical propulsion.

Spacecraft bus technology is the equivalent of our payload technologies but looking at just the spacecraft bus—the structure, the power system, control, onboard stationkeeping—all of the housekeeping functions that really can benefit by pushing technology, reducing the mass fraction, and improving reducing the weight so that more can be put on as payload and less on the spacecraft bus.

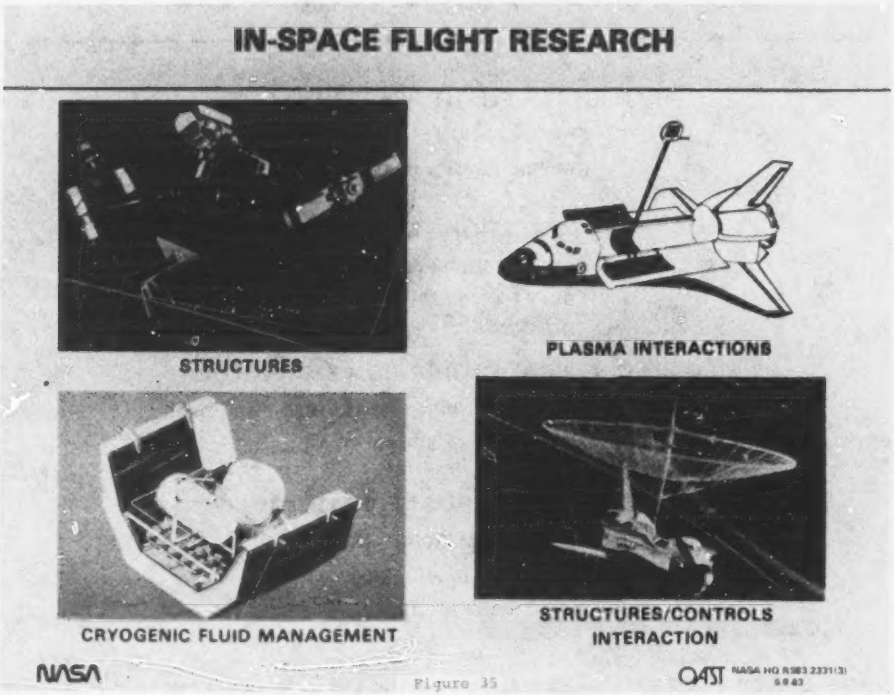


Figure 35

In space flight research on the next chart (figure 35) just summarizes some of the things that we're talking about. I mentioned the control of large structures and we see an assembly of a structure in the upper left-hand corner. Plasma interaction. As you go to higher and higher voltages, this becomes a serious problem and we can't get a handle on that in ground tests.

As we look to high power systems, in order to reduce weight, we would like to push the voltage up from that typical 28-volt systems we have now, and there is a threshold where you get plasma interaction and arcing at high voltage and we need to understand that and we need space flight experiments to do that. The storage and transfer of cryogenic fluids is keyed as space-based OTV and we need some research data to understand that and we have plans to fly as shown in the lower left-hand corner on the shuttle—cryogenic fluid management facility. And structures and controls interaction is a complex problem depicted by an antenna that I've already talked about.

SPACE STATION TECHNOLOGY

SUPPORTS INITIAL STATION AND EVOLUTIONAL GROWTH

TECHNOLOGY GOALS

- AUTOMATED OPERATIONS & SYSTEMS
- ADAPTIVE INFORMATION NETWORK
- REGENERATIVE LIFE SUPPORT
- ADVANCED AUTOMATED POWER SYSTEMS
- INTEGRATED THERMAL/ENERGY-MANAGEMENT
- ENABLE HUMAN CAPABILITY & PRODUCTIVITY
- HIGH PERFORMANCE AUXILIARY PROPULSION
- ADAPTIVE CONTROL SYSTEMS
- INTEGRATE MULTI-LINK COMMUNICATIONS
- DEPLOYABLE/ERECTABLE STRUCTURES & MECHANISM
- ADVANCED COMPOSITES/COATINGS

INITIAL THRUST

- DISTRIBUTED DATA ARCHITECTURE
- HIGH VOLTAGE/CAPACITY POWER
- TWO PHASE THERMAL CONTROL
- AIR/WATER LOOP CLOSURE
- DOCKING, DEPLOYMENT MECHANISMS
- LOW THRUST ON-BOARD PROPULSION
- CRYOGENIC FLUID MANAGEMENT

NASA

OAST

Figure 36

Space station—next chart (figure, 36), please—is an area of a driver for technology. We worked many of these technology areas before space station became a central focus in the agency. We look at it as a driver—as a push to explore a number of key technology areas and information systems, structures and controls, energy management that need to be done.

It's a long-term proposition. We are not looking just at the initial capability, whatever that might be, but, in view of the fact that we will—would be considering an evolving and evolutionary growth of that, we need to have the pipeline filled with advanced technologies all along the spectrum of time and we are putting in place plans to augment and will come forward in this year's budget process for 1985 an augmentation of some of the ongoing work that we have that needs to be pushed along.

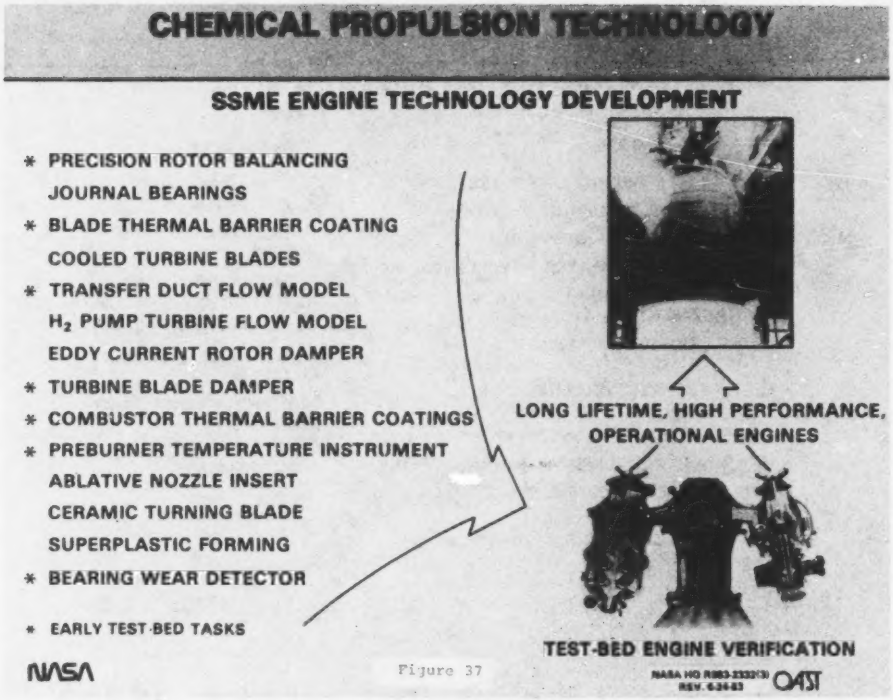


Figure 37

The next chart (figure 37) highlights our plans for 1985 to augment chemical propulsion technology. And we have had underway a very aggressive high pressure LOX-hydrogen technology base program that is generic in one sense but it utilizes the shuttle main engine as a focus—the most advanced engine we have and is the base from which we will build future engines and upgrade the performance and life of this engine, so it's a good technology driver. And, we have been pursuing a number of technologies as shown on the left of the viewgraph there and I've asterisked those that we think to be brought forward and evaluated in an actual engine environment.

We are proposing that, through a cooperative effort with the space technology program in my office and the Office of Space Flight—General Abrahamson—that we team up and he provide a test-bed function for us and we will develop advanced components that will be run in a test-bed function and we can evaluate their payoff and benefits.

ADVANCED OTV PROPULSION TECHNOLOGY

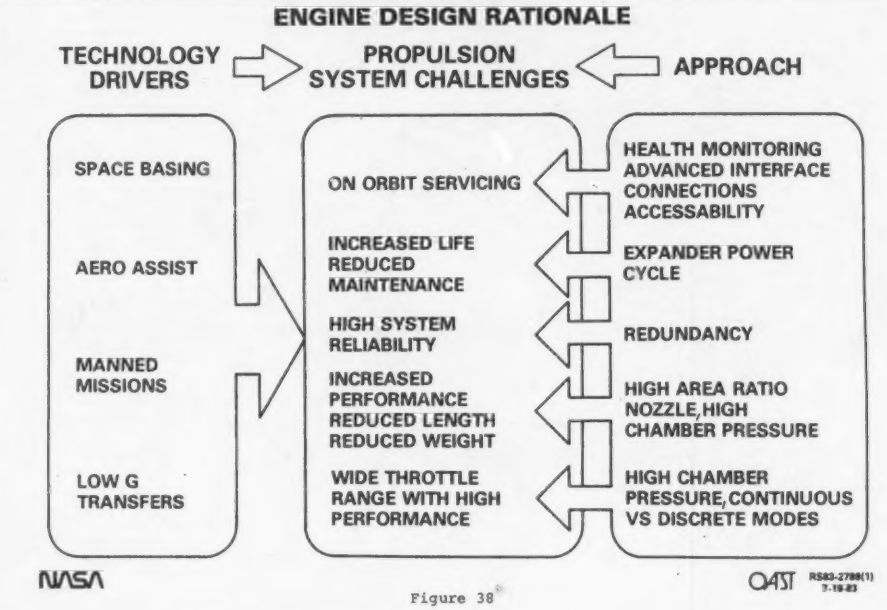


Figure 38

The next chart (figure 38) shows why we think that an increased emphasis in advanced OTV propulsion is necessary. And, when I refer to this it's really pushing the technology now, given the lead-time that we need in working propulsion and the complexities of advanced engines so that we can be in a position to make decisions in the early 1990's for an advanced engine for OTV in the mid-1990's. So it's not too early even though we are only talking about—or pointing toward a capability in the mid-1990's to start working the technology.

The RL–10 is a very good and reliable engine, but we are looking at a capability for a space-based OTV that has modular construction that you could disconnect and put new turbopumps in, quick disconnect lines, for a true space-basing capability. And the technology that needs to be worked to do that, as well as extended life and reliability for many, many reuses of such an engine is important, and we think we need to begin to work that. Although we have had underway in the base program an advanced technology program with Aerojet, Rocketdyne, and Pratt & Whitney, looking at the subcomponent advanced concepts. This would carry that to an engine system breadboard test.

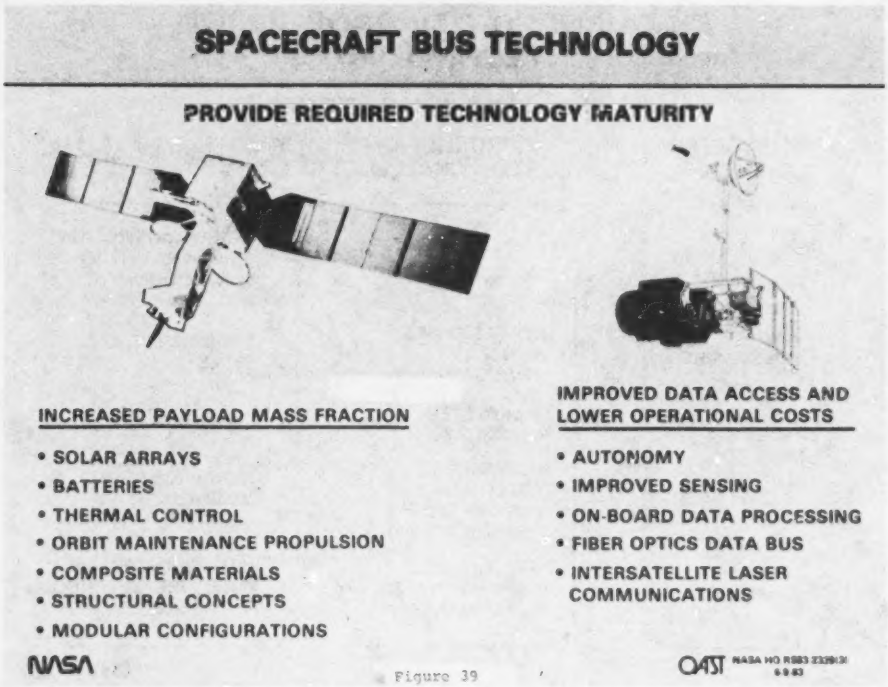


Figure 39

The next chart (figure 39) illustrates some of the things that we are planning in the last of the 1985 initiatives, that I had on that earlier chart related to spacecraft bus technology. It has everything but the payload—advanced solar arrays, batteries, advanced thermal control concepts, onboard propulsion, orbit maintenance, composite materials and structures, and the like. And, we think that that's very important in terms of the international competition that we're facing in commercial satellites, and, we think that we can play a role here in working selected, high-payoff technology supporting the commercial industry, just as we do in an analogous way to the way we support the aircraft industry through our aeronautics program.

And, in fact, that was a subject of a study by the Aeronautics and Space Engineering Board that the National Research Council did for us at our request to look at the space technology program, that the Agency was conducting, and assess as to whether it was supportive of the commercial satellite manufacturing industry and user community and, if not, what we should do and, furthermore, is there an analogous role that the agency should play in supporting the growing commercial applications in space as we do in aeronautics.

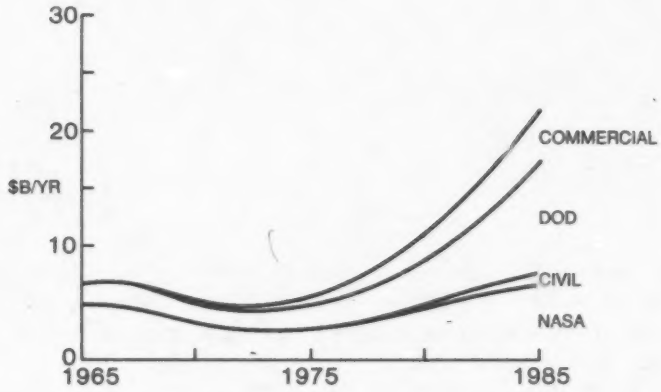
That report is just published—will be published—it's at the printer right now. It should be out next week. This is an advanced copy, and I think I have a chart, if you can skip the next chart and come back to it.

I stated the objective (figure 4). The participants covered a broad cross-section of industry, university, and Government members, chaired by Dr. Joe Shea at Raytheon. And, we had inputs from

even a wider cross-section than that and their recommendation was that we do expand the OAST role in support of a national space program analogous to OAST's aeronautics role, providing we do it in selected areas and capitalize on the access that the shuttle gives us to space for technology development.

And it's really the shuttle that is the equivalent of our wind tunnels. It gives us a unique capability that we feel is going to be able to establish the kind of team work that we need with the industry and universities where we can carry this technology into lower orbit. Why we want to do that is shown on the previous chart if you can back up one.

SPACE EXPENDITURE...INTO ITS GROWTH PHASE



NASA OAST

Figure 40

A program that—next chart (figure 40), please—in the early 1960's and 1970's, a technology program that supported and was structured around the Agency, NASA's needs, was appropriate. As you can see, we are the major investors in expenditures in space but that's no longer the case and it's going to become less and less the case in the future. We hope that NASA's involvement grows in the future but so will commercial and DOD applications.

To the extent we provide a base technology to support that growth, we think that we should—that the program should be structured to do that.

PROPOSED FY 1986 INITIATIVES

- SOLAR SYSTEM EXPLORATION TECHNOLOGY
  - SUPPORT TECHNOLOGY FOR SOLAR SYSTEM EXPLORATION COMMITTEE CORE PROGRAM
  - EHANCING DATA SYSTEMS, POWER SYSTEMS AND MANAGEMENT, AND CONTROL SYSTEMS TECHNOLOGIES
- LARGE DEPLOYABLE REFLECTOR TECHNOLOGY
  - 30 MICRON DEFRACTION LIMITED OPERATION
  - LARGE SEGMENTED OPTICS
- SP-100
  - HIGH CAPACITY FOR STATION, MANUFACTURING, SPACECRAFT
  - NASA/DOE/DOD JOINT PROGRAM

NASA OAST RS83-2782(1) 7-19-83

Figure 42

In fiscal year 1986, the next chart (figure 42) shows individual initiatives that we've identified for the 1986 budget year, recognizing the need to develop in a generic way technology supporting solar system exploration that Dr. Edelson talked about.

The next program, large deployable reflector technology, is also a joint cooperative effort with Dr. Edelson's Office in Space Science and Applications, really developing the technology for submillimeter astronomy and what's required in large aperture systems for that.

SP-100 is the code name for space nuclear reactor technology. As you are aware, we are undertaking now a critical technology program exploring the feasibility of a number of broad-range technologies that might be incorporated in a future reactor system that's joint with DOE and DARPA and if there are decision points all along in that program, the major one in fiscal year 1985 timeframe—that, if the technology proves feasible and we can lay out the right kind of program, then this would be the year that we would consider the start of a ground demonstration phase of that effort.

PROPOSED FY 1987 INITIATIVES

- ORBITAL TRANSFER VEHICLE TECHNOLOGY
  - SPACE BASING SUPPORTS SPACE STATION OBJECTIVES
  - AEROBRAKING ENABLING TECHNOLOGIES

- ENTRY RESEARCH VEHICLE AND EXPERIMENTS
  - MANEUVERING ENTRY FOR ATMOSPHERIC PLANE CHANGE
  - AEROTHERMAL PREDICTION VERIFICATION

NASA OAST RS83-2791(1) 7-19-83

Figure 43

The next chart (figure 43) is a similar fiscal year 1987 planned initiatives and I talked about the propulsion for orbital transfer vehicles as the long-lead item. The next—in 1987, we see the need to focus some of the technology in aerobraking for the return from GEO to LEO, using the atmosphere for aerobraking. And, finally, entry research vehicle and experiments—it's time we are starting to think about the use of remotely-piloted vehicles that we can evaluate high or L over D configurations in the shuttle for maneuvering entry vehicles.

SPACE TECHNOLOGY LONG RANGE PLAN
SUMMARY
• BROADENS NASA RESPONSE FOR SPACE TECHNOLOGY IN SUPPORT OF COMMERCIAL AND MILITARY SPACECRAFT BUS AND PAYLOADS
• PROVIDES FOCUSED TECHNOLOGY SUPPORT TO AGENCY GOAL FOR INITIAL AND EVOLVING SPACE STATION
• PROVIDES NECESSARY ENGINEERING RESEARCH CAPABILITY IN SPACE
• INCREASES TECHNOLOGY SUPPORT TO AGENCY GOALS IN COMMUNICATION, EARTH RESOURCES, AND SPACE EXPLORATION
• FOCUSES ON KEY TECHNOLOGY FOR UPGRADING AND EFFICIENT OPERATION OF THE SHUTTLE
• INCREASES OUT-OF-HOUSE RESEARCH PROVIDING RAPID, REAL TIME TECHNOLOGY TRANSFER TO U.S. INDUSTRY
• SUPPORTS LONG TERM, HIGH RISK RESEARCH
NASA
OAST

Figure 44

Finally, the last chart (figure 44) just summarizes where we think we stand in relation to the technology program of the future in the decade of the 1980's if we implemented all of these programs. We think it broadens the NASA response to space technology in support of a broader national role. It provides focused technology to support the Agency's goal of initial and evolving space station options; provides necessary engineering research capability in space—that's in-space flight experiments; increases technology support of agency goals in communications, Earth resources, and space exploration. It focuses on key technology for upgrading efficient operation for extended life of the shuttle. It increases which we feel is very important, the out-of-house R&D effort providing rapid and accelerated technology transfer to the industry, and then the bottom line is what we think our job is, supporting long-term—in areas of high risk for the agency and for the country.

That's the end of my prepared material, Mr. Chairman. I'll be happy to answer any questions that you might have.

Mr. VOLKMER. One that I have is just out of my own knowledge. I suppose I should know but I don't. It occurred to me that you are contemplating that the OTV would have to use quite a bit of propulsion fire. You are talking about a hydrogen LOX engine?

Dr. COLLADAY. Yes, sir, although with aerobraking and utilizing the Earth's atmosphere on the return trip, you drastically cut down the dependence on propulsion, but it would be a—if we can convince ourselves that we convince ourselves that we can store cryogenic fluids for a long period of time in space and handle the transfer and that storage problem. Clearly, the performance benefits lie with LOX hydrogen systems.

Mr. VOLKMER. Now, as I understand it, NASA's 5-year program plan forecasts a 15 percent per year growth in commercial invest-

ments in spacecraft development and operations. Does NASA intend to support commercial space research and development? If so, how?

Dr. COLLADAY. Well, as I pointed out, we think that, from the technology—research and technology standpoint, that we should and must support that industry in areas where we have a unique capability—either expertise or facilities and we are exploring the extent to which the program should be expanded to do that.

Mr. VOLKMER. Well, let's take the satellite manufacturing industry right now. From all of this that you show me, where—can you just give me an instance where that spacecraft bus technology—is the microphone on yet?

Dr. COLLADAY. That spacecraft bus technology program, Mr. Volkmer—structures and the analytical tools to control and satellite structures, advanced composite materials, power systems for satellite's stationkeeping propulsion; the housekeeping and maintenance on orbit of those satellites—everything but the payload. If you separate—if it's a commercial satellite and separate the communications payload, those technologies that I talked about would push the subsystem capabilities across the board and they would support advanced satellite design and construction that would put our industry at a competitive advantage to maintain U.S. preeminence in this field.

Mr. VOLKMER. Now, are we going to continue research and development? Things have been commercialized. We've got space communication. We've got the ACTS going up but what about expendable launch vehicles? Will we be doing further research and development in those things?

Dr. COLLADAY. We do have within the base program an active and aggressive communications technology program that will support whatever follow-on to ACTS there may be or it also is transferred directly to industry. But, we have underway in programs, both with the industry and through Lewis Research Center a fairly aggressive echnology program in communications and in sensing for remote sensing.

Mr. VOLKMER. What about the utilization of a new antenna in the future? If you'll continue, I guess, and do that, and some of that could be transferred to the communications system.

Dr. COLLADAY. That's right.

Mr. VOLKMER. What do you do to prevent duplication of research?

I notice in some of the centers—then, we have the laboratories and some of them were doing it basically in the same areas.

Dr. COLLADAY. We watch that very carefully to make sure that there is not unwarranted duplication. In some cases, it's intentional and desirable, but not very much of that and, in the duplication that we might note in the program, you see similar areas between centers, but they are involved in totally different aspects of that broad area.

We are also very conscious of making sure that we utilize the scarce resources we have in jointly planning and coordinating programs with the DOD to make sure there's no duplication. So it's an area that we are very concerned about and watch very carefully

and I think I can say that I don't feel that there is unwarranted duplication in the program.

Mr. VOLKMER. In other words, let's say that Johnson is working on a certain area and Lewis is working in that same area but they may be on different parts but would they then transfer the technology if, you know, as it comes on?

Dr. COLLADAY. One of the reasons why you see the R&D program based across all the centers is to be able to effect that smooth transition from the research centers—Ames, Langley, and Lewis—that might be working on the basic R&T end of the spectrum and get it into and transfer it into the development centers so that it can be used. We work very hard at getting the centers linked up between the research and the development centers.

Mr. VOLKMER. Is it correct to say that most of our technology effort is directed to things that involve lower Earth orbit?

Dr. COLLADAY. There is a—I would say that the majority of it is probably focused on low Earth orbit, although we do have an element in the program that is directed at planetary systems. But, if you rack that up against the total, the majority of it, I would say, would be directed at low Earth orbit.

Mr. VOLKMER. Is there any area in the interplanetary applications, you know, technology research that we need to be doing that you can think of that we haven't or are not doing right now?

Dr. COLLADAY. Well, the part that is probably the biggest technology driver in our program for planetary is that they works for other applications as well and that's in the area of autonomous systems.

Mr. VOLKMER. Right.

Dr. COLLADAY. Where we need to develop spacecraft that can identify faults, correct themselves, have a fair degree of artificial intelligence to be able to reconfigure and continue the mission without ground support.

Mr. VOLKMER. We have a few questions, but it's getting late, so we'll submit those to you in writing if you'll reply.

Dr. COLLADAY. OK, sir.

Mr. VOLKMER. We'll keep the record open for 2 weeks. We should be able to get the answers by then.

Dr. COLLADAY. OK, sir.

Mr. VOLKMER. I appreciate your being here. It's been very informative. I want to apologize for the time that you had to wait to be here, but I thank you very much.

This will conclude our hearings on the NASA's 5-year plan.

Thank you very much.

Dr. COLLADAY. Thank you.

[Questions and answers submitted for the record follow:]

RESPONSES TO WRITTEN QUESTIONS SUBMITTED BY CONGRESSMAN VOLKMER DURING THE HEARING BEFORE THE HOUSE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS ON JULY 28, 1983, TO DR. COLLADAY

QUESTION R-1:

What percentage of NASA's research and technology effort do you think is directly applicable to military applications? Do you anticipate a growth in NASA's DOD-related work and, if so, in what areas?

ANSWER R-1:

The NASA Space R&T progam is a broad-based, discipline-oriented, fundamental research effort that is primarily opportunity driven and is typically years ahead of identified application requirements. The fundamental character of the program, in most cases, leads to advances in technology that are commonly applicable to both civil and military applications. We have estimated the percentages of the budget that could have application potential to military and civil activities at 86 and 98 percent respectively. As is apparent, the sum of these greatly exceed the budget because of the program's synergistic value.

With the high degree of relevance of NASA R&T to military applications and the pressing needs of NASA programs it is not expected, at current budget levels, to see any signficant growth in the share of resources applicable to national security. There will, however, continue to be fostered a close working relationship through interdependency mechanisms that will optimize, for mutual advantage, NASA and DOD research and technology programs.

QUESTION R-2:

What steps are being taken:

a. to involve the universities more in space research?

b. to involve the industry more in space research?

ANSWER R-2:

The OAST Space R&T long range plan, as described to you in Dr. Colladay's testimony, states a key objective of ensuring balanced participation by NASA Centers, other government agencies, universities, and industrial organizations in space technology. University and industry participation in NASA R&T begins with their representation on advisory bodies where they are given the opportunity to review progress, accomplishments, and plans of this Office. Our intent is to increase NASA's capability for R&T planning and prioritization, and to provide an increased role in program implementation for both industry and universities. We will encourage greater cooperation between research centers, universities, and university consortia in the high risk areas of basic research. Greater industry participation in technology research and development will be pursued to expedite the transfer of new technology. It is planned to increase our dialogue and interaction with industry Independent Research and Development (IR&D) Programs and increase activities that provide conference forums for the exchange of progress and plans in research and technology.

QUESTION R-3:

Is NASA's 5-year Research and Technology plan predicated on a constant level of funding, excluding inflation, or does it depend on increased funding?

ANSWER R-3:

The long range plan is predicated on increased funding for augmentations that will accomplish the five-year planning objectives in a timely manner. If, however, current funding levels continue, adjusted only for inflation, planning objectives will be pursued but achieved at later dates.

[Whereupon, the hearing was concluded at 5:30 p.m.]

○